

# **LIQUEFIED NATURAL GAS IN BRAZIL**

ANP's experience in the  
implantation of LNG import projects

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## MOST USED ABBREVIATIONS

- ANP** – *Agência Nacional do Petróleo, Gás Natural e Biocombustíveis*
- Berr** – United Kingdom Department for Business and Skills, former Department for Business, Enterprise and Regulatory Reform (United Kingdom)
- CM** – Confirmation Memorandum
- CNE** – Comisión Nacional de Energía (Spain)
- CPAC** – Public Competition of Capacity Allocation
- DOE** – United States Department of Energy (United States)
- DOU** – *Diário Oficial da União*
- Enagas** – Empresa Nacional de Gas S.A. (Spain)
- Ferc** – Federal Energy Regulatory Commission (United States)
- Gaspetro** – Petrobras Gás S.A. (Petrobras' subsidiary)
- Gasfor** – Guamaré – Pecém Gas Pipeline
- GN** – Natural Gas
- GNL** – Liquefied Natural Gas
- GNV** – Vehicular Natural Gas
- GT** – Work Group
- HAZID** – Hazard identification
- HAZOP** – Hazard and operability studies
- LNG** – Liquefied Natural Gas
- MAS** – Master Sales Agreements
- MME** – Ministry of Mines and Energy
- PPT** – Priority Thermo-electricity Program
- UT** – Thermo-electric Power Station
- TAG** – Transportadora Associada de Gás S.A. (Gaspetro's subsidiary)







## PRESENTATION

The Brazilian natural gas industry has faced countless challenges over the last five years. In the economic plan, the still incipient transportation infrastructure and the aggravation in the national market supply insecurity by the Bolivian gas have posed restrictions to the product's offer, precisely at a moment in which the domestic natural gas consumption was increasing, due to, among other factors, the governmental stimulation of the demand increase.

In the regulatory field, the natural gas share increase in the Brazilian energy matrix cause the increase in the improvement of the standards in force, culminating in revisions of decrees and resolutions of ANP and the issuing of new regulations.

Within such environment, the need to increase the natural gas offer and its supply safety achieved more importance, in order to meet the national demand, as guided by *Conselho Nacional de Política Energética (CNPE)*. Thus, the construction of two LNG (Liquefied Natural Gas) regasification facilities was determined, one in Pecém, Ceará e another in Guanabara Bay, Rio de Janeiro. The facilities made the gas import feasible also from farther countries, such as for example, Trinidad and Tobago and Nigeria, besides de bordering countries, linked by gas pipelines.

This work originated in the Technical Note ANP/SCM Technical Note no. 12/2009 is intended to synthesize the experience acquired by ANP in the process of implanting CNL projects in the process of implanting LNG projects in the Country and in particular, the learning in the issuing of grants. This includes the experience of the countries visited by the technical team (United States, United Kingdom and Spain), descriptions of the built facilities, risks inherent to the liquefied natural gas industry and a brief description of the steps made by ANP for the proper proceedings of the administrative process involving these facilities.

Due to the success of this experience, ANP expects that this publication may serve as a source of information and consultation for those interested in the theme, as well as a guide for the future acting of ANP in the next LNG projects contributing to the regulation efficacy, for the growth of that market and for a higher security of the national supply.

**Haroldo Lima**  
**Executive Director**



## I. INTRODUCTION

The unbalance of the natural gas supply and demand conditions in Brazil over the last years, along with the uncertainties as to the supply of Bolivian gas, has imposed to the Country the need of adopting supply alternatives, in order to make the gas offer flexible and assure the continuing supply of that power source to the different segments of consumption.

The diversification of supply sources has become extremely important to mitigate the supply shortage risks. Thus, Liquefied Natural Gas (LNG) has become an important alternative to the pipeline transportation, mainly in the cases in which: (a) there are uncertainties about the delivery of the volume of gas traded with the exporting country; (b) the gas transportation network is still incipient or absent; (c) the pipelines are already operating at their maximum capacity; and/or (d) the total natural gas demand of a country is met by more than one exporting source, sometimes using different transportation modals.

Regarding the LNG commercialization costs, historically high, it is seen that little by little this alternative starts to be feasible in countries such as Brazil, for example, bringing changes to contracts and prices.

Besides, the Natural Gas Production Anticipation Plan (Plangás), carried out by Petróleo Brasileiro S.A. (Petrobrás) in Southeast Brazil, the Brazilian company urged two LNG projects located in Pecém (CE) and in Guanabara Bay (RJ) with capacity to re-gasify respectively, 7 million m<sup>3</sup>/day and 14 million m<sup>3</sup>/day.

Due to the LNG projects' originality in Brazil and their related activities, ANP's capacity building for the technical and economic operations involving the LNG commercialization has become necessary, in order to accomplish in a suitable form the analysis of the documents for granting the construction and operation authorization.

In view of the theme's relevance, this paper aims to present ANP's experience in the implantation of LNG projects in the Country. The text, based on the ANP Technical Note no. 12 of 2009 describes the LNG chain and the peakshaving facilities, draws a panorama of the market conditions which caused the construction of the LNG projects in the Country and the inputs import, pointing out the regularity milestone and the history of the first imports made.

The paper also shows the main characteristics of the LNG market in the three countries visited by ANP (United States, Spain and United Kingdom) with a brief scenario of the LNG world commerce at the present time. It also describes the risks related to the activity and the main incidents that have already occurred worldwide. It also deals with the technical features of the projects implanted in Guanabara Bay and in Pecém, of the granting process of construction and operation projects of LNG facilities and brings the reflections on the regulatory agency's learning.

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<sup>1</sup> Available at ANP's website: [www.anp.com.br/gasnotas](http://www.anp.com.br/gasnotas)

## II. LNG CHAIN

The LNG chain is a set of activities comprised in the natural gas industry aiming the transportation or the storage of the product in the liquid state, a situation in which it occupies a volume 600 times smaller than in the gas state.

### II.1. LNG Transportation

The LNG production is justified when the quantities or distances to be crossed among the production sites and the consumption locations are such, that it becomes economically unfeasible to carry the natural gas through the pipeline.

In such cases, the LNG value chain comprises the following activities: a) exploitation, production and processing of natural gas; b) liquefaction; c) transportation; d) storage; e) re-gasification; f) distribution to the consumer market. The sequence of steps is presented in Figure II.1.

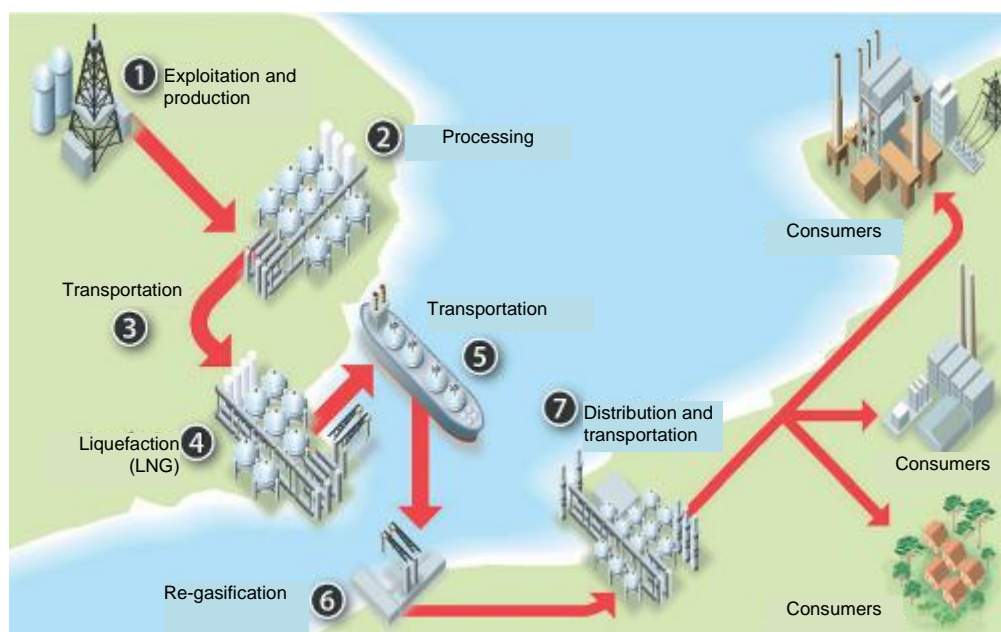


Figure II.1. LNG value chain (Adapted from OATLEY, 2008).

The liquefaction activity consists of a series of processes aiming to convert natural gas from the gas state to the liquid state. A liquefaction plant is comprised by one or more trains<sup>2</sup>, and it may contain facilities for storing the product for subsequent transportation or re-gasification.

Factors such as the gas composition, the quantity of gas to be produced and liquefied, and the product location (and, consequently, the liquefaction plant) exert a strong influence on the design of each liquefaction plant. In spite of each plant being unique, all perform the same procedures, namely: gas treatment for removal of impurities and product liquefaction by means of the cooling process (up to approximately 162° C negative, which is the temperature in which the natural gas is liquefied at the atmospheric pressure)..

<sup>2</sup> A train is a modular processing unit, which is an integrating part of the liquefaction plants, the sizes of which are limited by the compressors' capacity (Energy Charter Secretariat, 2007).

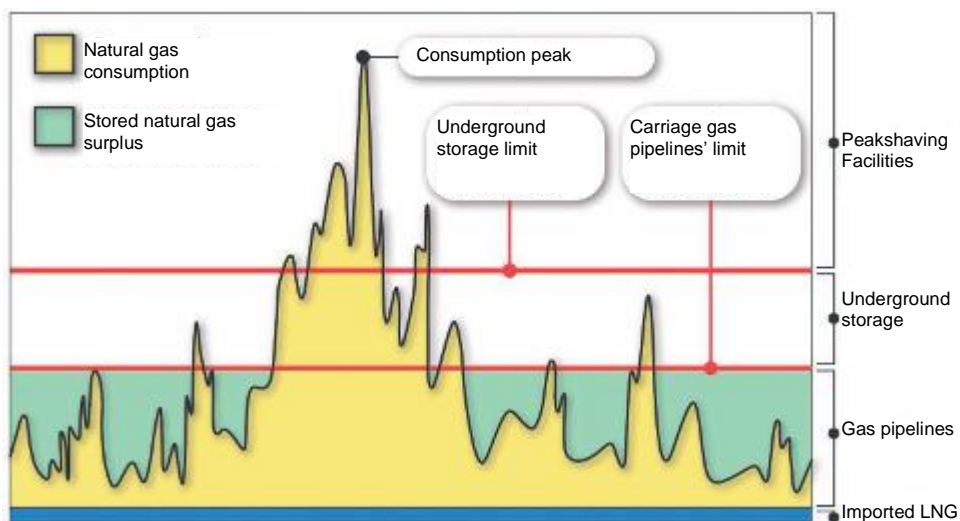
The LNG transportation may occur by means of methane carrier vessels or tank-trucks. The methane carrier vessels are normally used in the international trade, in which great distances are generally sailed, thus enabling scale economies. The tank-trucks are used to supply locations not supplied by the carriage gas pipelines' network, leading to the concept of "virtual gas pipeline", which is used to create a consumer market. Such vessels and trucks are provided with thermally insulated tanks allowing the natural gas to be kept in the liquid state.

Independently of the way the LNG is transported, upon reaching its final destination it must be submitted to a re-gasification process, which can be performed in its own plant or in a moving unit (ships and trucks), to be used then.

## II.2. Peakshaving facilities

Although the LNG produced in those plants is normally carried by means of vessels or trucks (denominated "virtual gas pipelines"), in countries where there are large gas consumption peaks, in certain times of the year, the natural gas may be liquefied and stored in the low demand periods for a subsequent re-gasification and utilization in the peak periods. Such facilities are given the denomination of peakshaving and take on the outstanding role in several countries, constituting the biggest part of the LNG facilities in the USA.

Figure II.2 shows the natural gas consumption profile of a country with a mature industry and in which several carriage and storage facilities for such product are available namely: (a) re-gasification facilities with contracts in the firm mode for the LNG import; (b) gas pipelines; (c) underground storage facilities; and (d) peakshaving plants.



**Figure II.2** - Yearly natural gas consumption and storage profile - underground storage and peakshaving facilities (Self-owned elaboration, from VITALE, 2009).

3 Recently, the LNG has been used to supply urban buses and trucks.

During the seasons of the year in which the gas consumption is lower than the pipeline carriage network capacity, the companies take advantage of that unused capacity to store the surplus volume in the underground and peakshaving storage facilities, for subsequent utilization. Such capacity is represented in green, in Figure II.2.

In the periods in which the demand is higher than the pipeline network capacity the stored gas is used to supply this additional demand, as it can be seen in Figure II.2. Another point to be highlighted is that the peakshaving facilities are used only during the demand peak days, due to the peculiar characteristics of those facilities, which is the one of being able to inject a large amount of gas in the system in a short time interval.

### III. BACKGROUND

Over the last years, policies of gas usage incentive were implemented in different consumption segments, which had a big impact on the demand increase by that power input.

According to the data from the “*Resenha Energética Brasileira 2009*”, referring to the year 2008, published by *Empresa de Pesquisa Energética (EPE)*, the natural gas represents today 10.2% of the domestic energy offer, against the 5.4% share in 2000 (EPE, 2009).

The evolution of the monthly average gas sales of the distributing companies in the period from 2000 to 2008 may be seen on Table III.1 below, by consumption segment: industrial, thermal generation<sup>4</sup>, automotive (Vehicular Natural Gas, VNG), residential and commercial.

**Table III.1** - Monthly gas average sales of the distributing companies per segment, expressed in thousand m<sup>3</sup>/day (Own elaboration from Abegás’ data).

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2007/2008 (% yearly)	2008/2009 (% yearly)
Industrial	12.917,1	14.828,6	16.579,7	18.459,6	20.256,9	22.487,2	24.265,5	25.267,2	25.743,9	1,9	9,0
Automotive	992,6	1.752,4	2.688,9	3.646,0	4.321,7	5.295,7	6.308,8	6.986,3	6.722,0	-3,8	27,0
Residential	495,8	462,6	491,5	538,8	593,0	607,3	649,8	661,5	597,2	-9,7	2,4
Commercial	287,6	304,3	361,9	407,4	447,5	706,6	556,4	582,6	587,7	0,9	9,3
Generation (includes co-generation)	2.155,6	5.271,3	6.956,7	6.100,2	10.322,6	11.349,6	9.670,4	7.266,3	15.915,2	119	28,4
Others (includes CNG)						165,3	310,3	265,5	172,9	-34,9	1,5
<b>Total</b>	<b>16.849</b>	<b>22.619</b>	<b>27.079</b>	<b>29.152</b>	<b>35.942</b>	<b>40.972</b>	<b>41.761</b>	<b>41.029</b>	<b>49.739</b>	<b>21,2</b>	<b>14,5</b>

The segments consuming most natural gas in Brazil are the industrial, electric generation and the automotive segments, followed by the residential and by the commercial segments, whose shares in the consumption are quite similar.

As it can be seen from the table above, the Brazilian natural gas demand presented an average annual growth rate of 14.5% yearly for the period set.

The segments which impacted the most such growth were those of electric generation (28.4% yearly) and the automotive (27% yearly). As to the industrial and commercial segments, they also presented high rates, although less expressive than those of the previous sectors, from 9.0% yearly and 9.3% yearly, respectively.

<sup>4</sup> The difference between the sales values by the distributing companies and the full offer data available results mainly from the consumption of the refineries and of the nitrogenous fertilizers plants belonging to Petrobrás.

Taking into account the period 2007/2008, a natural gas demand growth rate of 21.2% yearly was reached, mainly driven by the strong increase gas consumption intended for the electric generation which reached 119.0%. That may be explained mostly by the higher need of dispatch of the natural gas thermal power stations.

From the point of view of the industrial and automotive consumers, the reason for the demand increase lies, mostly in a deliberate price policy of stimulation to the use of natural gas, in which the lower gas price before its direct competitors (fuel oil, liquefied oil gas, gasoline and alcohol) was determined in order to make its quick adoption feasible, making up for the conversion costs.

With this, the capacity deemed idle of the Bolivia-Brazil Gas Pipeline (Gasbol) was intended to be depleted, in view of the engagements made by Petrobrás to take-or-pay 80%<sup>5</sup> and ship-or-pay of 100%<sup>6</sup>, respectively with Yacimientos Petrolíferos Fiscales Bolivianos (YPFB) and Gas TransBoliviano S.A. (GTB), in Bolivia, and with Transportadora Brasileira Gasoduto Bolívia-Brasil S.A. (TBG) in Brasil.

Thus, from the years 2003 to 2004 Petrobras kept the natural gas prices practically unchanged (PETROBRAS, 2008).

Furthermore, the company instituted in 2004 the Natural Gas Massive Use Program <sup>7</sup>, which counted on the support of the Federal Government and of the State Governments, which granted tax incentives to the potential clients to stimulate the gas utilization, trusting that its price would be kept competitive in the long term.

Thus, industrial plants were changed to make the natural gas utilization feasible as fuel, gas thermal power stations were built, and automobiles were converted to use VNG among other initiatives.

Regarding the thermal generation, the Thermo-electricity Priority Program (PPT) created by the Ordinance no. 3.371/2000 was intended to stimulate the construction of Thermo-electric Power Stations (UTEs) to promote an alternative to the hydric power generation, and for such, it established, among other prerogatives, differentiated natural gas prices for the thermal power stations included in the PPT. Ever since this incentive has promoted the increases seen in the gas consumption intended for the electric power generation.

Thus, in view of the Brazilian hydro-thermal electric generation model, one imagined that when the level of the hydro-electric power stations reservoirs presented insufficient generation capacity to supply the demand, only a thermal clearance would suffice. However, by the late 2006, a final availability test of the UTEs using natural gas as fuel was made, for the Brazilian Southern and Southeast/Mid-Western markets. The result has shown a generation in average 42.8% below that programmed for the whole of the test power stations, and the number of 85% was due to the gas unavailability or lack (ANP, 2007)<sup>8</sup>.

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5 A take-or-pay clause requires the buyer to pay for the gas, even when it has not been effectively consumed.

6 The carriage contracts generally contain minimum payment clauses, independently of the volume carried in fact, referred in the market as ship-to-pay, consisting in a duty paid in counterpart to the gas pipeline capacity reserve. This type of duty is related to the firm carriage service.

7 For more detail, see lecture "Natural Gas Massive Use Program" pronounced by Ilso Sauer, who was then the Director of Gas and Energy of Petrobras, in the IV Brazilian Congress of Power Planning - Itajubá, on March 26, 2004. Available at <http://www.iee.usp.br/biblioteca/producao/2004/Trabalhos/Sauer.pdf>.

8 The UTEs availability test comprised the period from 00h00 of the day 12/11/2006 to 24h00 of the day 12/21/2006 and it was accomplished by the National Electric System Operator (ONS) in compliance with the Authorization Resolution no. 755 of November 30, 2006, issued by Agência Nacional de Energia Elétrica (Aneel).

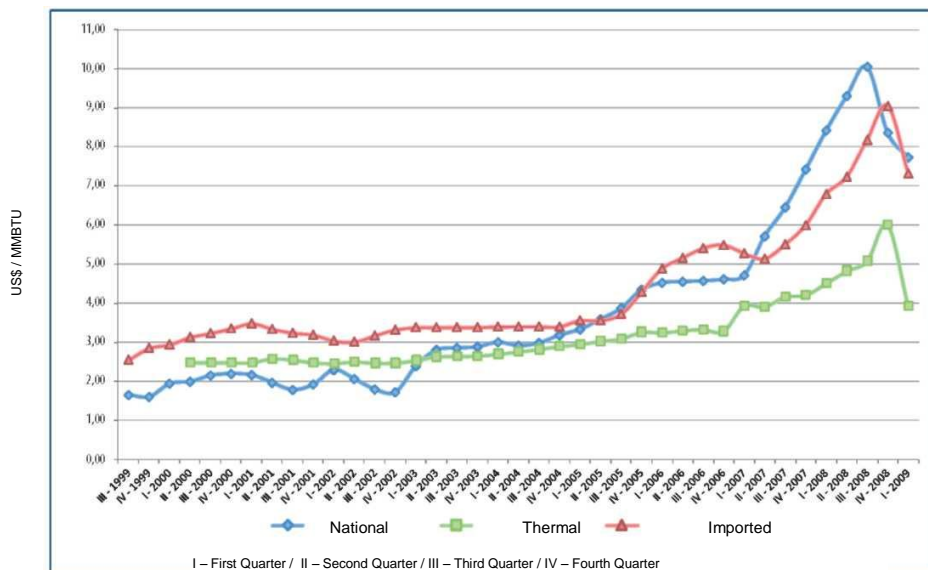
So, from 2005 to 2006 the natural gas demand by the UTEs presented a 14.8% drop, staying under the value required by the National System Operator (ONS).

If, on one hand, the Natural Gas Massive Use Program contributed to increase the natural gas competitiveness in the Country and its penetration in the Brazilian power matrix, on the other hand, intensified the risk related to the unpredictability of the power price variations.

Thus, from 2005 on, one may notice a movement of the national natural gas prices increase. From the mid 2007's to mid 2008's on, this price increase movement in the city gate 9 was intensified both for the national origin natural gas and for the imported gas and for the gas intended for the PPT thermal power stations.

From late 2008's on, the gas prices curves started to show inflection, resulting from the reversion of the market conditions, as it can be seen in Figure III.1 below.

In fact, in that period, the oils basket price used as reference to quote the price of the nationally produced natural gas was impacted by the low prices of raw oil barrel practiced in the international market during the year 2008, as compared to the prices seen in 2007.



**Figure III.1** – Prices in the national, imported natural gas city gate and PPT program, in US\$/million BTU's referring to the period from the 3rd quarter of 1999 to the 1st quarter of 2009 (elaboration from PETROBRÁS data of 2009).

**Notes:**

- Natural gas sold as being national gas: average prices not weighed with PIS/Cofins and without ICMS.
- Natural gas sold to the thermal power stations: average prices not weighed without PIS/Cofins and ICMS.
- Natural gas sold as imported gas: average prices not weighed without PIS/Cofins and ICMS.
- Commercial dollar by the monthly sale average (Banco Central Ptax).

9 Also referred to as delivery point, city-gate is the facility where the moved product is delivered by the Carrier to the holder of a natural gas volume that has contracted the carriage service. Generally, that facility contemplates filtering, heating, pressure decrease and measurement systems for contractual and tax purposes.



From the supply side, its growth in the recent years even if being an expressive one, has appeared to be insufficient to meet the totality of the national demand. When during a test late in the 2007's natural gas thermal power stations were simultaneously cleared to check the actual gas supply capacity required for the electric power generation to supplement the hydric power generation, the impossibility of gas delivery to such thermal power stations was evidenced again, without restraining the consumption of other classes.

Besides, Petrobras made punctual cut-downs in the gas supply to the natural gas distribution company of the State of Rio de Janeiro, CEG-Rio, causing, for example, interruptions in the consumption of Norte-Fluminense Thermal-Electric Power Station in September 27 and on October 13, 2007, and an increased reduction in November 24 of the same year (ANP, 2008). Supply shortages situations were also punctually seen in stations licensed to service the VNG consumer. However, such cut-downs did not exceed the volumes set forth in the natural gas purchase and sale contracts.

The insufficiency of gas supply ruled the search for better power policy solutions for the suitable compliance of the total national demand, both for the thermal power stations aiming the electric generation as to the industrial, residential, automotive and other segments.

Furthermore, those episodes contributed to boost the need to clearly establish the gas delivery priority order per consumer class in contingency situations.

Law no. 11.909 of 3/4/2009 also known as Gas Law, provides in its Chapter VII, Art. 50 the possibility of suspending the gas supply obligations in activities within the Federal Government competence, and of rendering carriage service in situations characterized as contingencies. The same law foresees the elaboration and execution of a contingency plan, to be regulated by the Executive Power in a specific standard. Such plan should provide on: (a) initial measures, as they fit; (b) measures mitigating the gas offer decrease; (c) priority consumptions; and (d) distribution of eventual gas offer decreases in an isonomic form, once the priority consumptions and the logistic restrictions are complied with (Art. 51, § 1, Law no. 11.909/2009).

Thus, in the context of the Brazilian natural gas industry instability, due to uncertainties related to the supply of natural gas from Bolivia, since the nationalization of the hydrocarbons in May 2006, and to the increasing of the supply risk perception and also of the risks of a new power crisis in Brazil alternatives were assessed and implemented.

Thus, as of the late 2006's Petrobras performs the Natural Gas Production Anticipation Plan (*Plano de Antecipação da Produção de Gás – Plangás*) comprised of natural gas exploitation and production, processing and carriage projects in Southeastern Brazil, aiming to increase the gas offer in that region, from 15 million m<sup>3</sup>/day to 40 million m<sup>3</sup>/day along 2008 and subsequently, 55 million m<sup>3</sup>/day in 2010.



Notwithstanding the recent evolution in the natural gas supply and demand commented previously from the late 2008's to the first semester of 2009, the Brazilian gas market has shown a shrinkage as a consequence of the international crisis effects on the credits market, which started by the mid 2008's and which expanded worldwide.

Such crisis, allied to the wet period (December to April) in which the hydro-electric reservoirs' level remains high and decreases the need of thermal clearance, affected the national consumption of natural gas, mainly in the industrial and electric generation segments.

According to the statistics of *Associação Brasileira das Distribuidoras de Gás Canalizado (Abegás)*, the sale of gas from the distributing companies for the generation and co-generation of electric power fell down from 16.1 million m<sup>3</sup>/day in December 2008 to 5.9 million m<sup>3</sup>/day in April 2009, a drop of approximately 63.7%.

As to the industrial consumption, as an effect of the international crisis that hit Brazil, presented a strong inflection from October 2008 on, falling from 26.5 million m<sup>3</sup>/day in that month, to 19.3 million m<sup>3</sup>/day in April 2009, a 27.4% drop in that period.

Besides, as seen, the strong natural gas prices readjustment practiced by Petrobras for the distributing companies also caused impacts on the natural gas demand, since it lost competitiveness in view of the fuel oil, for example, its main substitute.

Reflecting the decrease in the internal demand, the production of non-related gas fields was decreased, as well as the Bolivian gas imports. However, as of May 2009, the natural gas market in Brazil started to show signs of recovery and its perspectives, expressed in Petrobras' 2009 Business Plan are that the non-thermal-electric market shall grow in average 6% yearly from 2009 to 2013.

Thus, the conditions of repressed demand and restrictions in the supply that were in force during the year 2005 until the mid 2008's, both due to the production limits and to the existing carriage infrastructure limits, stimulated the initiatives of national production increase, the investments in carriage infrastructure and the flexibilization of the supply with the construction of the LNG projects in the Country.

Such conditions continue to dictate, to a certain extent, the investments in carriage capacity and higher supply safety, aiming to decrease the bottlenecks existing in the pipeline system and to avoid the risks of power lack that have already made part of the national scenario.

In short, due to the large dependence on the Bolivia gas (approximately 50%), and the political-institutional instability in that Country, added to the natural gas market growth, it became urgent to create reliable alternatives of supply to meet the national demand. Thus, besides the increase of the national supply, the import of LNG has taken an important role in the search for continued natural gas supply in Brazil.

#### IV. LNG ENTRANCE IN BRAZIL

One of the main changes seen over the last years in the natural gas industry worldwide was the increase of the gas penetration in the power matrix of different countries and the more and more used option of marketing the product through the LNG.

In the context of the natural gas supply in the Brazilian market and of the national production increase policy, two re-gasification terminals were built to make the LNG import feasible – which became a major option to increase the reliability in the natural gas supply in Brazil.

The first initiative to assure the full implementation of the activities concerning the LNG and in order to overcome possible problems with its fulfillment, was the issuing by *Conselho Nacional de Política Energética (CNPE)*, of the Resolution no. 4 of 11/24/2006 which set forth directives for the implementation of LNG import projects, in order to “assure a reliable, safe and diversified natural gas supply”.

Based on this administrative act and in its Business Plan 2007-2011, Petrobras presented two LNG import terminals’ projects, one in Pecém (CE) and the other in Guanabara Bay (RJ) with capacity to re-gasify respectively, 7 million m<sup>3</sup>/day and 14 million m<sup>3</sup>/day.

The owner of all assets comprising those projects is Transportadora Associada de Gás S.A. (TAG), a whole-owned subsidiary of Petrobras Gás S.A. (Gaspetro), and the carrier company is Petrobras, being responsible for the acquisition of LNG in the international market and for the freighting of the tank ships with the company Golar LNG Ltd. In its turn, Petrobras Transporte S.A. (Transpetro) shall render operation and maintenance services to TAG, through the signature of an O&M Contract with that carrier.

Then, TAG requested from ANP the authorization to build the facilities integrating the referred projects. That Agency, after reviewing the required documentation, granted the Authorizations no. 464 and 465 of 12/18/2007. The first of them refers to the construction of the Pecém –Gasfor Port Gas Pipeline and to the disassembly of the seven loading arms of liquid by-products in Pier 2 of Pecém Port, assets integrating the LNG Project in Pecém. The second one, in its turn, refers to the construction of the LNG Pier Gas Pipeline – Campos Elíseos and the Campos Elíseos Station, the latter located in the municipality of Duque de Caxias (RJ).

In short, the LNG Project in Pecém comprises: (a) the facilities for receiving LNG, re-gasification and outflow of natural gas in Pier 2 of Pecém Port; and (b) the gas pipeline interconnecting that LNG terminal to the existing carriage gas pipelines system, the Guamaré- Pecém Gas Pipeline (Gasfor). Intended solely to outflow the natural gas coming from the Pecém LNG terminal this gas pipeline is 20 inches in diameter and 19.1 km in length, with 100 kgf/cm<sup>2</sup> maximum pressure.

That terminal received the first Temporary Operation Authorization, issued by ANP on January 7, 2009 for the commissioning of natural gas of the Arm no. 7 of re-gasified natural gas transfer for injection in the pipelines’ network, and of Gasfor. Subsequently, new temporary operation authorizations were issued for commissioning all the other pier arms and facilities.

As to the LNG Project in Guanabara Bay, it covers the installation: (a) of the equipment for receiving LNG, re-gasification and outflow of natural gas in the LNG Pier of Guanabara Bay; and (b) of the gas pipeline interconnecting that LNG terminal to the Campos Elíseos Station. This gas pipeline is solely intended to outflow the natural gas coming from that pier and is 28 inches in diameter, with 16 km in length and 100 kgf/cm<sup>2</sup> maximum pressure.

On March 10, 2009 ANP issued the first temporary operation authorization for commissioning the LNG transfer arms of the Guanabara Bay Terminal and subsequently, issued the temporary operation authorization for commissioning all the other Pier arms and facilities.

The history of the construction and operation authorizations granted by ANP is object of the Section IX.4.

In order to follow-up those projects, ANP published the Ordinance ANP no. 217 of November 30, 2007 which instituted a Work Group (WG) comprised of experts of the Agency, aiming the analysis and issuing of opinions and supplementary documents referring to the projects. That WG based the decisions of the ANP Collegiate Board as to the granting of construction and operation authorizations.

Finally, it should be reminded that in spite of the characteristic originality of those projects, the first Brazilian experience with the commercialization of LNG started in 2005 with the implementation of the Gemini Project, developed by the companies *White Martins Gases Industriais Ltda.*, *Petrobras* and *GNL Gemini Comercialização e Logística de Gás Ltda.*

In the Gemini Project, Petrobras is in charge of supplying natural gas, and White Martins is in charge of operating the Liquefaction Unit it owns, and GNL Gemini is in charge of the activities of distribution and marketing of LNG.

Such project consists of the liquefied natural gas production in a liquefaction plant located in the city of Paulínia – SP, with capacity of 380 thousand m<sup>3</sup>/day, and of its subsequent distribution and commercialization in regions whose channeled gas distribution systems are not well developed or do not exist. This undertaking meets clients located in the Federal District, and in the States of Espírito Santo, Goiás, Minas Gerais, Paraná, Rio de Janeiro and São Paulo and aims basically the Liquefied Petroleum Gas (LPG) market, characterized by short term contract and by the lack of fidelity to the suppliers (ANP, 2005).

#### **IV.1. Regulatory compliance**

The legal rules that founded the procedures for the LNG entry in Brazil were the Ordinance ANP no. 170/1998 (to be discussed ahead), and ANP Resolution no. 27/2005 regulating the use of the natural gas pipeline carriage facilities through suitable pay to the carrier.

According to the latter rule, all available carriage capacity for the contracting of the Firm Carriage Service (STF) in carriage facilities shall be offered and allocated according to the procedures of the Public Contest of Capacity Allocation (CPAC). Art. 7 of ANP Resolution no. 27/2005 provides as follows:

“Art. 7. (...)

§1 The Carriage Capacity in projects that were not commissioned shall be object of the CPAC accomplishment, except for the projects under process of environmental licensing or of public interest declaration on the date this Resolution is published.

§ 2 The Carrier shall submit to ANP’s approval, within thirty (30) days before the disclosure, the CPAC regulation, which shall detail the offer and allocation procedures of the capacity for STF.

Single paragraph. The Carrier should elaborate and forward to ANP within sixty (60) days before its application, the contract forms provided for in the caput hereof.”

Thus, the LNG facilities would be subject to the referred public procedure for offer and allocation of firm capacity of natural gas carriage. However, in view of the projection of high risk levels for the Brazilian electric system in the analysis horizon of up to three years, and consequently, the need to prioritize the fulfillment of the thermo-electrical power stations, the Resolution CNPE no. 4/2006 was issued as commented previously.

This Resolution has declared, in its Art. 1:

“...the prior and urgent implementation of Liquefied Natural Gas Projects (LNG) comprised by the natural gas import in the cryogenic form, storage and re-gasification, as well as the required infrastructure, aiming to:

- I - To assure the natural gas availability to the national market aiming to prioritize the fulfillment of the thermal-electric power stations;
  - II - To facilitate the adjustment of the natural gas offer to the national market characteristics, by means of a flexible supply;
  - III - To mitigate risks of natural gas lack of supply due to abnormalities;
  - IV – To diversify the imported natural gas supplying sources; and
  - V - To decrease the deadline for implementing natural gas supply projects”.
- (highlights from the authors).

Therefore, before the need of making the offer flexible and to assure the supply of natural gas to the thermal-electric power stations, due to the risk of power deficit in the order of 20% (much higher than the 5% level deemed acceptable by ONS), the urgency of starting the implantation of the LNG Projects was deemed decisive for the non-fulfillment of the CPAC in that case.

Another major aspect to be pointed out refers to the obligatoriness of access to the carriage pipelines and sea terminals existing or to be built, as set forth by Art. 58 of Law no. 9.478/1997 (Law of Oil). Such access permission through proper remuneration to the facilities’ titleholder shall not be applicable to the LNG facilities, since Law no. 11.909/2009 (Gas Law) has released it.

The Gas Law changed Art. 58 of the Oil Law as follows:

“Art. 58. Any concerned party shall be entitled to use the carriage pipelines and the sea terminals existing or to be built, except for the Liquefied Natural Gas – LNG terminals, through proper remuneration to the titleholder of the facilities or of the natural gas movement capacity, in the terms of the law and of the applicable regulation.” (highlights from the authors).

And so Art. 45 of the Gas Law also determines as follows:

“Art. 45. The production outflow gas pipelines, the natural gas treatment or processing facilities, as well as the liquefaction and re-gasification terminals are not required to allow access by third parties.” (highlights from the authors).

Finally, it should be said that CPAC shall be replaced by a public call: “procedure with access assurance to all those concerned, which is intended to contract the carriage capacity in existing pipelines, to be built or expanded” (Law no. 11.909/2009, Art. 2, VII).

The public call for contracting the carriage capacity aims to identify the potential carriers and size the effective demand, and shall precede the granting of authorization or bidding for granting the carriage activity.

Such call, like CPAC, shall also be promoted by ANP, according to directives of the Ministry of Mines and Energy (Law no. 11.909/2009, Art. 6) and besides, at the end of its process, terms of engagement shall be signed between ANP and the carriers for the purchase of the requested capacity (Law no. 11.909/2009, Art. 5, §3).

However, such device shall not apply to the LNG facilities, because as it was already mentioned, these are not subject to the free access.

## **IV.2. LNG Imports: history of the ANP authorizations**

Be the mid 90's, the first studies for the implantation of projects aiming to import LNG were performed. These first evaluations, led by Petrobras and by Shell Brazil, were related to the supply of natural gas to Northeastern Brazil, focusing on meeting the demand from new projects of gas thermal-electric generation.

By November 1998, the two companies signed an agreement aiming to evaluate both technically and economically the implantation of a terminal for receiving LNG in the Port of Suape (PE), with operations foreseen to start in the year 2004.

With the justification of making the negotiations progress with the product supplier feasible, Petrobras and Shell Brazil requested to ANP in the terms of Ordinance no. 43 of April 15, 1998 the granting of authorizations, for both companies, for exerting the activity of LNG imports from Nigeria. The two requests together totaled the volume of up to 7.6 million m<sup>3</sup> natural gas /day or up to 2 million tons LNG /year.

To that effect, ANP granted to Petrobras and to Shell Brazil respectively, the Authorizations no. 32 and 33, of 3/26/1999, published in *Diário Oficial da União* (DOU) of 3/29/1999. However, due to the waiving of the companies in the implantation of the Suape LNG terminal, the validity term of those authorizations expire after a year in force, and there are no renewal requests of them by the concerned companies.

It was only in January 2008 that the negotiations with the regulating agency were resumed to start the activity of LNG imports in the Country. Such initiative was in charge of Petrobras, through the presentation to ANP of the application with the authorization request to import up to 33,300 m<sup>3</sup> natural gas/day to be acquired in the spot market, without a previously set supplier, which may vary from one product load to another.

In July 2008, after forwarding the required documentation to comply with the regulation in force, ANP authorized Petrobras to exert the activity of LNG import, in the terms of Ordinance no. 43/1998. According to Authorization no. 257 of 7/8/2008, published in DOU of 7/9/2008, the LKNG shall be acquired by Petrobras in the spot market and shall be intended to meet the demand for electric generation, and eventually, of supplying the channeled gas distributing companies. The LNG shall be carried by means of methane ships up to the delivery sites in the Guanabara Bay (RJ) and Port of Pecém (CE) Sea Terminals, where its re-gasification shall occur in moving and flexible stations installed in LNG carriage ships duly adapted for that purpose.

It should be pointed out that the Ordinance no. 43/1998 has not set forth a treatment differentiation between the natural gas import by gas pipeline and the LNG import. Thus, some of the requirements set forth herein are outdated for the LNG market, especially as regards the world growing trend of the spot market relevance for the product's acquisition.

So, it was agreed between ANP representatives and Petrobras that, in order to comply with Art. 3, §1, of Ordinance ANP no. 43/1998, the Master Sales Agreements (MSA) signed with the potential LNG suppliers were submitted to ANP in replacement of the natural gas Purchase and Sale Contracts required by the regulation at issue, which are not compatible with the contracting form in the LNG spot market.

The MSA is a type of non-binding pre-contract by which the non-commercial LNG purchase and sale clauses are established. In the act of closing a spot business, the parties sign a Confirmation Memorandum (CM), containing the specific commercial terms and conditions of that negotiation, the pair MSA/CM constituting a binding contract.

On that account, and in view that ANP is also the agency responsible for the consent of the natural gas import licenses in the Integrated Foreign Trade System (Siscomex), ANP may request the presentation of the CM, or of other documents and information, whenever there are questionings on the data stated in the LNG import licenses, previously to their approval by ANP, safeguarding the confidential nature of the commercial character clauses presented to the regulating agency.

It was based on such premises that the granting of Authorization no. 257 of 7/8/2008, published in DOU of 7/9/2008 was made. For such, Petrobras submitted to ANP the copy of the MSA model to be signed with its potential suppliers, for the contracting of LNG in the spot market, as well as the authenticated copy of the MSA signed with Total Gas & Power Limited, dated of October 19, 2007, and entitled "Master Sale and Purchase Agreement for Spot LNG". It was agreed between ANP representatives and Petrobras that for granting such authorization, the contractual instruments signed with all potential suppliers were not required, but those documents may be requested at any time by ANP.

Besides, for granting the authorization, Petrobras has certified that the LNG to be imported would meet the technical specifications contained in Resolution ANP no. 16 of 6/17/2008.

Petrobras started the LNG import in the month of November 2008, with the arrival of the first methane carrier ship in the Terminal of Pecém (CE), as it is shown in Table IV.1 and Figure IV.1. The date was collected from the monthly activity reports, sent by Petrobras in the terms of Art. 6 of Ordinance no. 43/1998.

All LNG imported loads up to the present date came from Trinidad and Tobago. ANP granted the previous consent to each one of such loads through the approval of the respective Import Licenses in Siscomex.

In Table IV.1, the column boil-off corresponds to the loss of ship cargo in the steps of carriage, transshipment and storage. According to the data provided by Petrobras, the average losses are 0.2% a day in the methane carrier vessel travel, of up to 1.5% a day in the transshipment and of 0.15% a day during the storage (vessel anchored). The boil-off of the LNG cargo imported in the month of November 2008 was approximately 24% of the total imported, due to the long waiting time of the vessel in the Terminal of Pecém (CE).

**Table IV.1** - Quantities of natural gas imported through LNG by Petrobras (Source: ANP/Petrobras).

	Country of origin	Destination	Measured volume (m <sup>3</sup> LNG)	Equivalent volume (m <sup>3</sup> Gas)	Available power (million BTU)	Consumed boil-off (million BTU)
Nov/08	Trinidad & Tobago	Pecém (CE)	57.872,10	34.723.262,40	1.278.717,00	395.558,00
Dec/08	-	-	-	-	-	-
Jan/09	-	-	-	-	-	-
Feb/09	-	-	-	-	-	-
Mar/09	Trinidad & Tobago	Baía de Guanabara (RJ)	52.000,00	31.200.000,00	1.172.315,00	-
Apr/09	Trinidad & Tobago	Pecém (CE)	50.538,46	30.323.078,40	1.140.155,00	279.611,00*
May/09	-	-	-	-	-	-

**Note:**

\* According to Petrobras, the boil-off consumed in March 2009 since the departure of the ship from Trinidad & Tobago, was entered in the last discharge of that vessel in Pecém (CE), in April 2009.



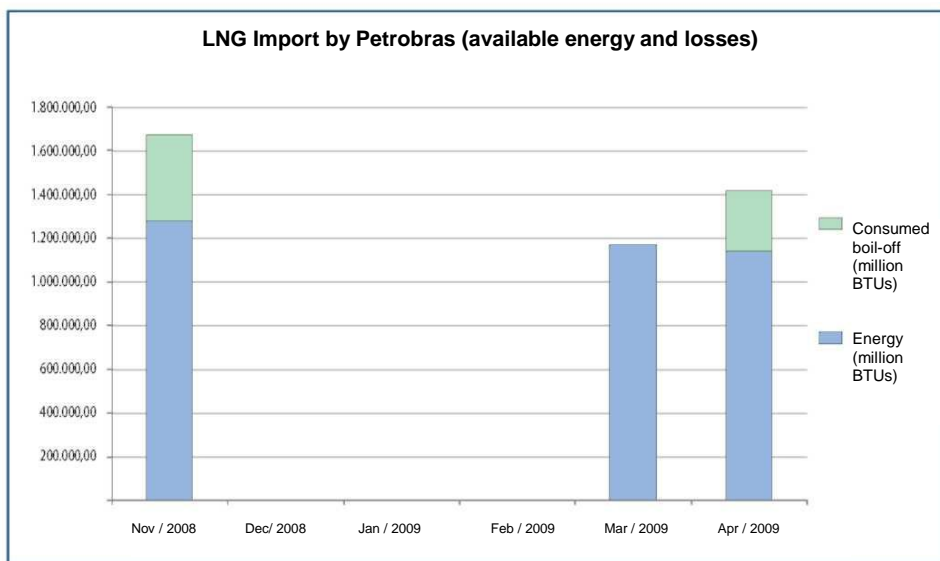


Figure IV.1 - Evolution of the LNG import in Brazil from November 2008 to April 2009 (Source: ANP/PETROBRAS).

Finally it should be pointed out that Law no. 11.909/2009 transferred to the Ministry of Mines and Energy (MME) the attribution of granting the authorizations to exert the activities of natural gas import and export. MME shall comply with the directives set forth by CNPE.

ANP waits for the publication of the ordinance that shall regulate the referred law so that its new responsibilities in this link of the natural gas chain are set. It is supposed that ANP starts to instruct the authorization requirement processes to MME, and it shall also be in charge of inspecting, following up and practicing all accessory acts required for the regulation of that activity.

## V. CURRENT PANORAMA OF THE WORLDWIDE LNG MARKET

The LNG market is predominantly regional worldwide, that is, the exporting countries dedicate themselves to supply the closest importing countries, in spite of the recent cost decreases in that carriage mode.

Initially, the higher demand for LNG in the USA, as well as in the United Kingdom, benefited the producers from Western Africa and the Caribbean, but it was soon noticed that the increase of the demand in the Atlantic Bay higher than the offer of the local producers should be supplied by external projects, especially those from the Middle East, highlighting the Qatar (HUITRIC, 2007). To a large extent, cost issues regarding the LNG delivery to long distances lost part of their relevance with the recent introduction of longer trains and carrier ships, allowing that movement.

From 2000 to 2005, all projects implemented in the Middle East were intended to meet the market of The Atlantic Basin (HUITRIC, 2007). Due to its strategic position, the Middle East became the ideal swing supplier<sup>10</sup> in the current market situation, especially for Qatar, which can deliver LNG both to the West and to the East of the Suez Canal.

However, technical character restrictions to the different LNG specifications to be delivered and to the capacities of the re-gasification terminals to withstand bigger carrier ships still remain (HUITRIC, 2007). Nevertheless, mechanisms have been recently developed to find technical solutions for those initial problems.

As a reflex of the sales increase to the Atlantic Basin markets, the short term transactions started to have a considerably higher share in the LNG sales along the last years.

Table V.1 presents the volumes effectively negotiated among the exporting and importing regions in 2008, measured in billion cubic meters. As it can be seen, the Asia-Pacific region is still demanding more than one half of the moved LNG volume, while Europe ranks second, with Spain and France representing approximately three quarters of that demand, and Mexico, responsible for the remaining volume. As to North America, represented predominantly by the volume demanded by the USA (73.4%) was accountable for 6.0% of the worldwide LNG demand in 2008. In the present context, the demands of the South and Central Americas (Argentina, Dominican Republic and Puerto Rico) are only marginal, representing less than 0.7% of the worldwide demand. The entrance of Argentina in the importing countries scenario is worth showing, with the commissioning of the LNG terminal in Baía Blanca.

**Table V.1** – LNG imports and exports per region in the year 2008, in billion cubic meters (BP, 2009).

Importing regions	Exporting regions						Total imports
	North America	South and Central Americas	Middle East	Europe	Africa	Asia-Pacific	
North America	-	13,38	-	0,52	10,09	-	23,99
South and Central Americas	-	1,10	-	-	-	-	1,10
Europe	-	2,67	0,14	7,59	42,94	-	53,34
Asia-Pacific	1,18	1,00	-	50,09	8,59	87,12	147,98
<b>Total exports</b>	<b>1,18</b>	<b>18,15</b>	<b>0,14</b>	<b>58,20</b>	<b>61,62</b>	<b>87,12</b>	<b>226,41</b>

It may be seen from the numbers above, that the Asia-Pacific region still appears as the greatest LNG exporter, boosting the regional character of that market. Ranking second and third we find respectively Africa to meet the European demand, especially Spain and France, and the Middle East, to meet the supply contract signed with Japan and South Korea. The exports by the South and Central Americas are made solely by Trinidad & Tobago with destination, above all, to the North American and Spanish markets. As to the businesses between North America and Asia, refer to the exports from Kenai Peninsula in Alaska, to Japan, which started in 1969.

<sup>10</sup> The countries denominated swing suppliers are those apt to supply different markets, with different contractual modes, being able to perform international arbitrations of prices and meet unforeseen demands, thus benefitting from the recent increase in the LNG prices volatility.

The distribution of the current and future LNG demand is in Table V.2 below, showing the status of the re-gasification terminals rated as: operating, under construction and under approval stage. According to the data presented, it is seen that currently, 64 re-gasification terminals are operating in 22 countries. Japan, United States, Spain and Korea hold approximately 67% of the facilities. Considering the facilities in operation and under construction all over the world, one may reach 83 LNG re-gasification terminals in a nearby horizon.

Country	Re-gasification plants status			Total	Country	Re-gasification plants status			Total
	Operating	Under construction	Planned			Operating	Under construction	Planned	
Japan	26	3	2	31	Portugal	1			1
United States	8	2	35	45	Dominican Republic	1			1
Spain	5	2	1	8	Thailand		1		1
South Korea	4			4	Philippines			3	3
United Kingdom	3	1	4	8	Netherlands			3	3
Italy	2		11	13	Indonesia			2	2
India	2	1	7	10	Pakistan			2	2
France	2	1	2	5	Sweden			2	2
Mexico	2		6	8	Germany			1	1
BRAZIL	2		1	3	South Africa			1	1
Turkey	2			2	Bahamas			1	1
China	1	2	15	18	Cyprus			1	1
Formosa	1	1		2	Croatia			1	1
Chile	1	1		2	El Salvador			1	1
Canada	1		6	7	Arab Emirates			1	1
Argentina	1			1	Ireland			1	1
Belgium	1			1	Jamaica			1	1
Greece	1			1	New Zealand			1	1
Kuwait	1			1	Poland			1	1
Puerto Rico	1			1	Singapore			1	1
				<b>TOTAL</b>		<b>64</b>	<b>19</b>	<b>45</b>	<b>198</b>

**Table V.2** - Current location and situation of the re-gasification facilities (ZEUS, 2009a).

**Note:** the LNG re-gasification facilities projects in Brazil shall be object of a section of its own (Chapter III) herein.

It is worth mentioning also the number of projects of terminals under construction and/or approved in China and in the United States, independently of their rated capacities, which reveals the intention of both countries to diversify their power sources, mainly due to supply safety questions.

It is important to notice that most of the new re-gasification facilities – under construction and planned – are located in the Atlantic Basin (except for the Continental Europe), totalizing 56 projects located in Brazil, Jamaica, Mexico, United States, Canada and United Kingdom, thus increasing the total number to 72 facilities in those countries.

The increase in the number of re-gasification terminals in the Atlantic Basin intensifies the trend to flexibilization in the worldwide LNG market, thus increasing its liquidity and thus favoring the accomplishment of businesses with smaller and smaller terms (spot market and contracts with maximum terms of up to five years), such as those seen mainly in the USA and in the United Kingdom.

It is important to notice that India and China are under a process of immediate expansion of their import capacity, increasing further their share in the Asia-Pacific region in the LNG consumer market.



Both countries may be deemed major potential markets, especially for China, which, followed by the United States, is one of the countries with the highest number of re-gasification terminals projects under construction and approved, as it was previously pointed out.

In response to the demand increase, it is also seen on the offer side, a growth in the number of natural gas liquefaction plants currently under construction and under planning. Table V.3 shows the location of the current plants in operation (and eventual capacity expansions) of the plants under construction and of projects planned worldwide.

Based on the presented values, supposing that all projects under planning shall be concluded and that shall be added to the plants already under construction, the number of liquefaction units (trains) shall tend to double worldwide, in a medium term horizon (2015), increasing from the current 88 to 178 facilities. In the short term, one can say that two new countries shall soon enter the restricted group of exporters: Yemen and Angola, because their first liquefaction plants are now under construction. As to the countries intending to enter that market as exporters, but with plants still under planning, they are as follows: Iran, Papua New Guinea, Venezuela, Canada, Islamic Republic of Mauritania, Peru and Turkey.

An important information concerns the number of projects of capacity expansion under accomplishment or planned by the major current LNG exporters: Qatar, Indonesia, Algeria, Malaysia, Nigeria, Trinidad and Tobago, Australia and Egypt, countries that together were responsible in 2008 for approximately 83.9% of the worldwide exports. Of special concern is the effort of expanding the capacity of the three countries located in the African Continent (Algeria, Nigeria and Egypt). Those recent movements added to the previously mentioned ones, concerning the demand, boost the increase trend of the LNG market flexibilization and of an eventual convergence in the pricing process.

**Table V.3** - Location and current situation of the liquefaction facilities (ZEUS, 2009b).

Country	Liquefaction plants status *			Total	Country	Liquefaction plants status *			Total
	Operating	Under construction	Planned			Operating	Under construction	Planned	
Indonesia	13	1	5	19	Equatorial Guinea	1		1	2
Qatar	11	4		15	Norway	1		1	2
Malaysia	8		1	9	United States	1		1	2
Australia	6	1	27	34	BRAZIL			1	1
Brunei	5			5	Yemen		2		2
Trinidad and Tobago	4		2	6	Angola		1	1	2
Egypt	3		3	6	Iran				9
Abu Dhabi	3		2	5	Papua New Guinea				4
Libya	3			3	Venezuela			2	2
Oman	3			3	Canada			1	1
Algeria	18	2	1	21	Islamic Republic of Mauritania			1	1
Russia	2		3	5	Peru			1	1
Nigeria	6		11	17	Turkey			1	1
					<b>TOTAL</b>	<b>68</b>	<b>11</b>	<b>79</b>	<b>178</b>

\* Self-contained LNG production modules (trains)

Curiously, the only country appearing currently both in the list of importing countries and in the list of exporting countries is the United States, which have this characteristic as a function of the old supply contractual engagements with Japan and due to its large territorial dispersion.

In order to conclude this section, Figure V.1 presents the major current natural gas flows in the world, both by means of carriage pipelines and by LNG. In the present context, the countries located in the Middle East and in Africa as a result of their privileged geographic condition, appear to be the only ones which can meet simultaneously the demands of the main basins, meeting long term contracts signed with the consumers in the Pacific Basin, or meeting the newly-rediscovered Atlantic Basin market, in which the in-sight and short term negotiation modes prevail.

Brazil is in the influence area of the North-American and European markets, thus sharing the same supply options of those, in special the production coming from Eastern Africa (Nigeria and Algeria) and Trinidad and Tobago.

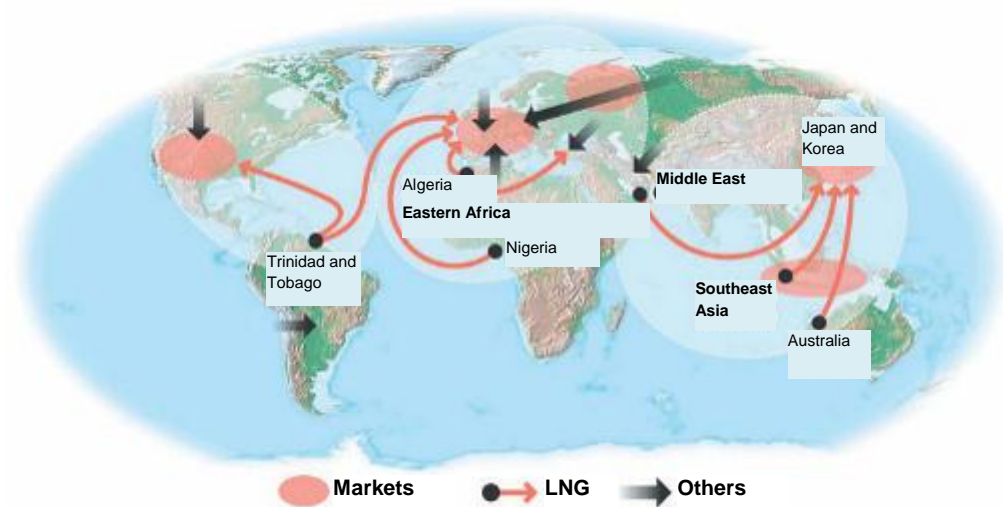


Figure V.1 – Major natural gas flows in the world (elaborated by the BG GROUP, 2007).

## VI. INTERNATIONAL EXPERIENCE

As shown in Chapter I, as part of its learning, the ANP Technical Group has performed international missions to the United States, United Kingdom and Spain, which included visitations to governmental agencies, LNG plants, designers and normative institutions. Next, see the detailing of such visitations.

### VI.1. United States

In the USA, the LNG projects are submitted to sub-legal laws and rules, the latter established by the Federal Energy Regulatory Commission (Ferc), by the US Coast Guard (USGC), by the US Army Corps of Engineers and by the North-American States.

The Energy Policy Act of 2005 has established Ferc as the authority for reviewing the projects of LNG terminals.

It is important to point out that even after the approval of the project by Ferc, it is necessary also that the economic agent obtains authorizations from other state institutions to build and operate their facilities, complying, for example, with the Clean Air Act and Clear Water Act the inspection of which is in charge of the Environmental Protection Agency (EPA), the North-American environmental agency.

For the LNG facilities, there is the division of attributions among regulating entities according to the terminal location. If designed or built on the coast (shore-side LNG terminals), Ferc is in charge of actuating as main regulator, while when planned offshore (LNG deepwater ports), that function should be taken by the USCG. The USCG authority for deep waters terminals was established by the Deepwater Port Act of 1974, by the Deepwater Port Modernization Act, of 1996 and by the Maritime Transportation Security Act (MTSA) of 2002.

Both agencies, Ferc and USGC have attributions similar to those of the Brazilian public environmental agencies, being responsible for the issuing of environmental permits and licenses. Ferc and USGC articulate between themselves and with the Department of Transportation (DOT), the agency having, among other attributions, the regulation of the USA pipeline network (including the one related to the LNG facilities), aiming to assure the facilities' safety. These institutions follow the construction stages of the LNG terminals. Figure VI.1 below shows in a schematic form, the division of attributions among the main federal entities in the regulation of the LNG facilities.

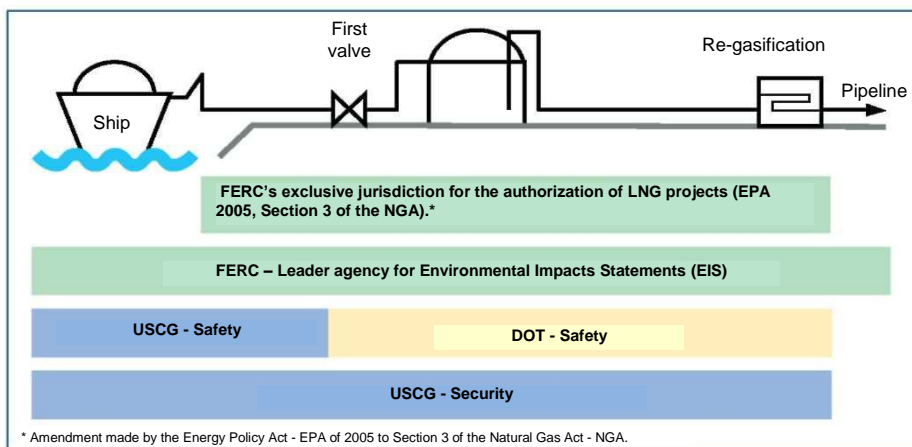


Figure VI.1 - Ferc, USCG and DOT jurisdiction for LNG facilities (Elaborated from ZERBY, 2009).

It should also be pointed out, as shown in the figure above, that Ferc concentrates its efforts in every chain under the jurisdiction to assure the environmental adequacy of the projects (Environmental Impact Statement). In its turn, USCG is responsible for assuring the security of the terminals (that involves, for example, procedures for the prevention of terrorist acts), located offshore or on the coast.

Figure VI.2 below shows the main LNG terminals' projects existing in the USA and approved by Ferc in its coastal jurisdiction, while Table VI.1 lists its main characteristics.



**Figure VI.2** - Main LNG terminals' projects existing in the USA and approved by Ferc, operating or under implementation (Elaborated from FERC, 2009b).

**Table VI.1** –Main LNG projects in the USA (Adapted from GDF Suez; Ferc; Energy Current; El Paso; DOE, 2008; Ecoelectric; Cheniere, 2008; Panhandle).

Terminal	Location (State)	Year of construction/ operation	Capacities	
			Tankage (million m <sup>3</sup> )	Re-gasification
Distrigas of Massachusetts LLC	Everett (Massachusetts)	1971	96.28	28,32 million m <sup>3</sup> /d
Dominion Cove Point LNG	Calvert County (Maryland)	1972	413.4	22,65 million m <sup>3</sup> /d
Elba Island LNG (El Paso)	Elba Island (Georgia)	1972	201(a)	33,98 million m <sup>3</sup> /d (a)
Kenai LNG Export Terminal	Cook Inlet Basin Area (Alaska)	1976	Not informed	2,78 billion m <sup>3</sup> from 04/01/2009 to 03/31/2011 (b)
Guayanilla Bay LNG	Guayanilla Bay, Peñuelas, (Puerto Rico)	1996-2000	96	461 megawatts electric co-generation
Free Port LNG (d)	Quintana Island (Texas)	2008	189.7 (d)	42,47 million m <sup>3</sup> /d (d)
Sabine Pass (d)	Cameron Parish (Louisiana)	2008 (d)	286 (d)	39,6 million m <sup>3</sup> /d (d)
Trunkline LNG Company, LLC	Lake Charles (Louisiana)	1977	254.8	50,97 billion ft <sup>3</sup> /d

(a) Capacities at the end of the expansion project named Elba III Project, in progress;

(b) Gas export volume authorized by the Department of Energy – DOE;

(c) In 1996, Ferc authorized the terminal construction and in 2000, the DOE authorized the LNG import;

(d) According to Cheniere, those terminals are still under construction or expansion. However, according to Ferc, they have received the first LNG cargo in April 2008.



It should be pointed out that the approvals of the LNG projects by the Committee do not bind their accomplishment. Ferc approves in a single act (Order Issuing Certificate) the construction, operation and maintenance of a LNG Terminal.

In the USA, the market defines whether a plant shall be built or not, while the concern and adequacy of the intended project to the environmental protection, industrial safety and public concern protection is the duty of the regulatory agencies. Figure V1.3 below shows all LNG projects approved in North America. From the 23 projects approved in the USA territory (three of which under the US Coast Guard jurisdiction) only 7 are effectively under construction or expansion works.

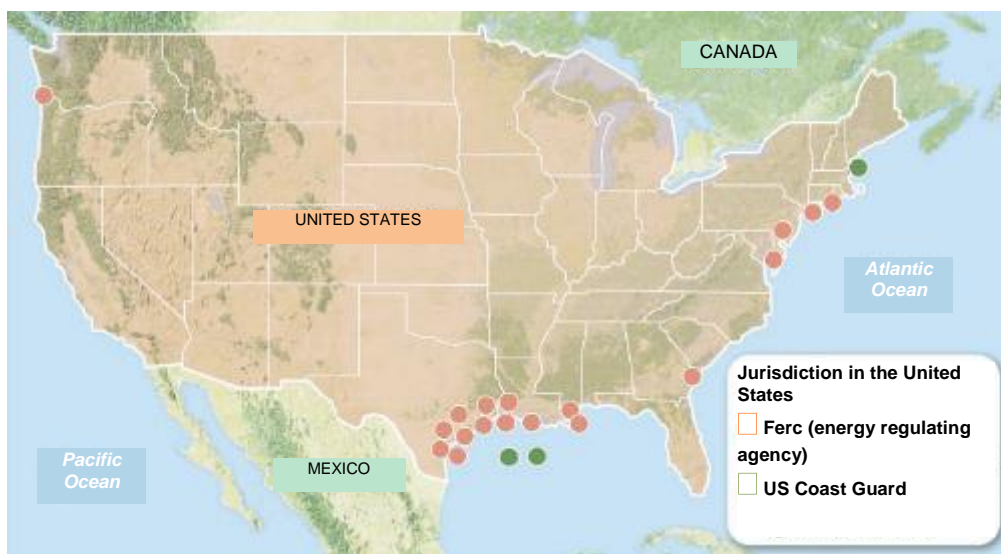


Figure VI.3 – LNG projects approved in North America (Elaborated from FERC, 2009b).

While Ferc and USCG, among other public institutions, are responsible for approving the LNG terminals' location, construction and operation, the Department of Energy (DOE) is in charge of regulating the oil and natural gas import and export regulation, including liquefied products. This is the attribution of the Office of Oil and Gas Global Security and Supply, Office of Natural Gas Regulatory Activities, department of DOE which also identifies opportunities for the USA private industry, develops programs and implements policies aiming to increase the international competitiveness of the North-American natural gas industry (DOE, 2009).

Finally, it should be pointed out that, as a form of stimulus to the LNG sector, the free access to new facilities is not mandatory yet. The Energy Policy Act of 2005 which determined the jurisdiction of Ferc upon the LNG projects has also set forth that the LNG terminals are not subject to free access until 2015, as a form to stimulate the implantation and funding of the projects.

Regarding the LNG facilities' safety, the main standards are listed in the Title 49, Chapter I, Part 193 of the North-American Code of Federal Regulations.

Besides the LNG terminals mentioned herein, there are onshore facilities generally under the jurisdiction of state agencies. The peakshaving facilities of Philadelphia (Pennsylvania), storing and re-gasifying liquefied natural gas for the period of highest consumption (winter) and the liquefaction and distribution facilities, by means of tank-trucks of Houston, Texas, are examples of those plant types.

## VI.2. United Kingdom

The United Kingdom is an interesting case in the world gas market, for having going recently – in 2004 – from the condition of supplier to the condition of energy importer due to the fall of its production, along with the consumption increase, especially for the electric generation. In Great Britain, the unbundling already exists since 1996 between the figures of the loader/producer and of the gas carrier, with access without discrimination to gas pipelines (open access).

The Department for Business, Enterprise and Regulatory Reform (Berr) is the agency responsible for the elaboration of reforms and adjustments in the regulatory milestones, also having the attribution of regulating the oil and gas industry and energy in the British Continental Platform, since the Office of the Gas and Electricity Markets (OFGEM) have jurisdiction on the onshore facilities.

In 2005 the consumption of natural gas in the United Kingdom was 103,000 million m<sup>3</sup>. The national production was sufficient to meet 93% of the consumption and the remaining 7% were imported, mainly during the winter.

According to the Berr, in 2020, the United Kingdom shall probably import approximately 80% of the natural gas required for its supply. Thereunto, a policy of natural gas import was adopted based in the competition. In terms of the consumer market, the demand profile per segment in 2005, was that shown in Figure VI.4.

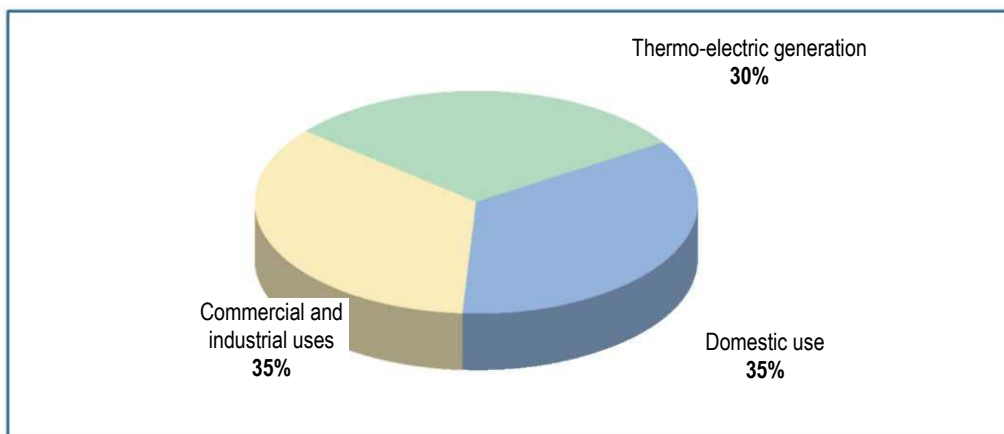


Figure VI.4 – Consumption division in 2005 (BERR, 2008).

Figure VI.5 below shows a map of the natural gas industry infrastructure in the United Kingdom.

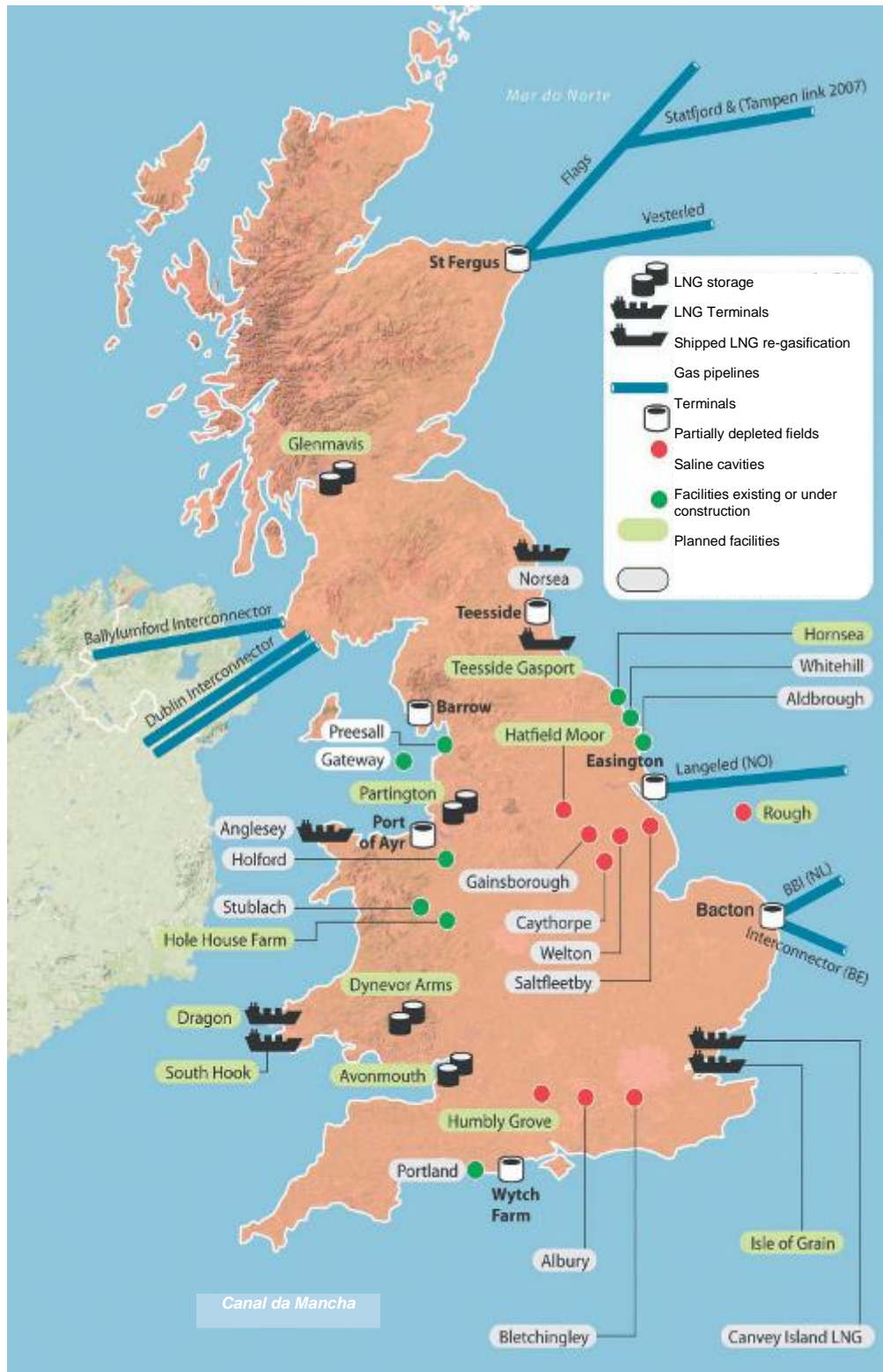


Figure VI.5 - Natural gas industry infrastructure in the United Kingdom (elaborated from HARVARD, 2007).

From the Figure VI.5, it is possible to identify four LNG units operating or in the final construction stage in the United Kingdom and three ones are planned. The facilities in operation or in its final implantation stage are, in Wales, Dragon LNG (visited by the ANP technical mission in 2008) and South Hook, and in England, the Isle of Grain. There is also in Scotland, the Teeside Terminal, with a setup similar to that of the Brazilian projects of Pecém and Guanabara Bay, which currently is in operation. The Anglesey (Wales), Canvey Island (England) and Norseia (Scotland) terminals are under planning stage.

Compared to that of the USA, the United Kingdom regulation is much less prescriptive. In America, new technologies take longer to be introduced than in the United Kingdom, because in the United States the technological evolution may only occur after the elaboration by the regulating agencies, of detailed standards, specific for the technology to be introduced, which does not happen in the United Kingdom.

In the United Kingdom, the regulation is based on studies considering the risks analyses of each project. Specialized companies quantify the risks of new projects, coach the operators and set the operating and safety procedures.

### VI.3. Spain

One of the most marking aspects of the Spanish gas industry was the big increase in the consumption by the thermal power plants in the last decade. In 2006 for example, the industrial sector was responsible for 52% of the natural gas consumption, followed by the thermal segment for the electric generation, with 34%. As to the domestic commercial segment, it has demanded 13% of the total consumed, while the use as raw material represented only 1%. Such sharp increase, allied to the inexpressive national production and to the large distances to the natural gas producers, makes the country highly dependent on the LNG imports for the domestic supply. In order to minimize the risks inherent to such dependence, Spain instituted the binder of the diversification of suppliers, through the Royal Ordinance 1716/2004 of 7/23/2004, which determined also the establishment of minimum safety reserves (SPAIN, 2004).

Therefore, the Spanish LNG plants play a crucial role for increasing the gas system flexibility and for the higher diversification of the supply sources, according to the data presented in Figure VI.6.

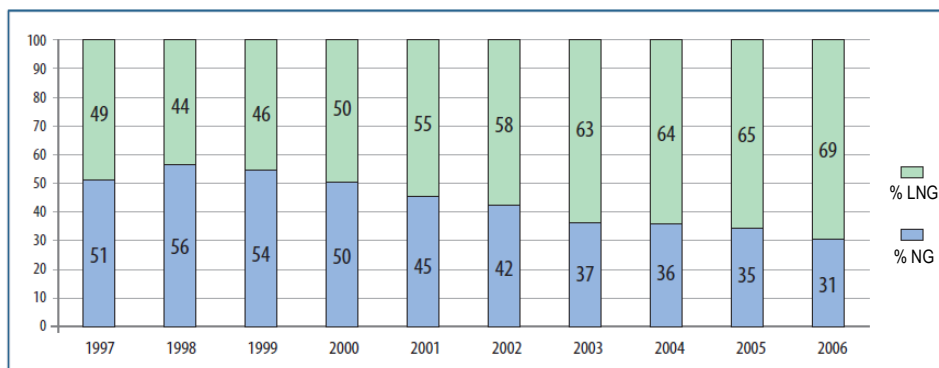


Figure VI.6 - Rate of the gas and LNG offer in Spain: Evolution 1997-2006 (CNE, 2007).

Six natural gas re-gasification plants shall be installed with capacity to re-gasify 49 billion m<sup>3</sup> LNG. Furthermore, there are two underground natural gas storage facilities the full capacity of which is 3,536 thousand m<sup>3</sup>. Although such capacity is deemed insufficient, it has an important function in the required market balance and in the operating flexibility due to the demand seasonality, which was the fruit of temperature variations along the year in the European Continent. Figure VI.7 shows the storage and re-gasification capacity of the LNG plants installed in Spain, present in that Country for 40 years already.

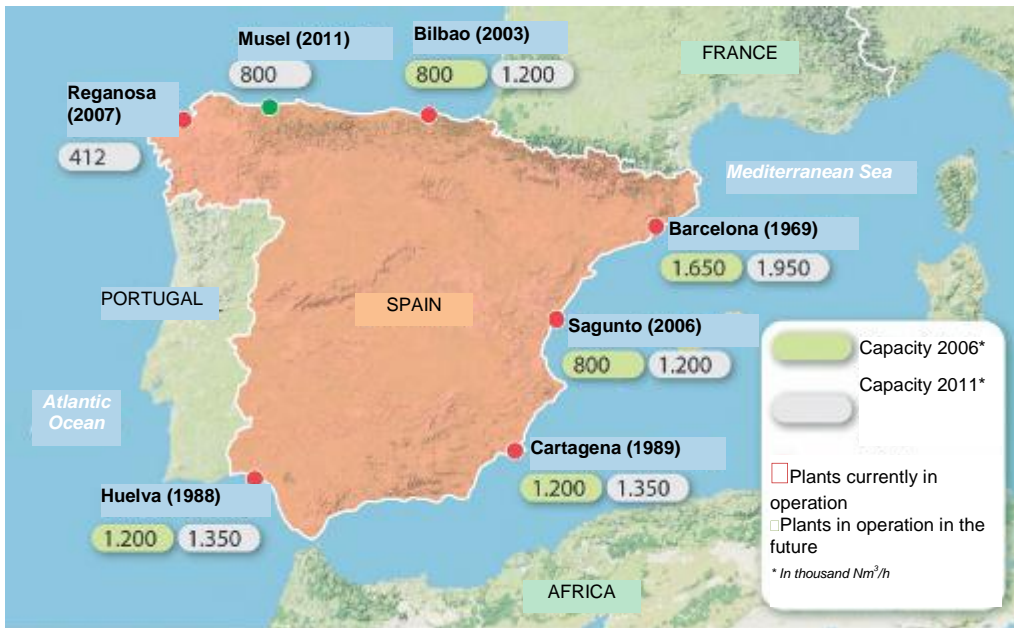


Figure VI.7 – Spain LNG re-gasification facilities (Elaborated from ENAGÁS, 2007).

Regarding the regulation of natural gas in Spain by sectors, the start of the industry release process occurred in 1998 with the publication of the Directive 98/30/CE and of the Law 34/1998 of Hydrocarbons (Ley de Hidrocarburos). That Law has set forth: (a) the introduction of the competition in the gas industry and a more open regulation; (b) the accounting separation between the activities of re-gasification, storage, carriage and distribution; (c) the judicial separation between the commercialization activities and all the other regulated activities; and (d) the regulated access to third parties concerned in using the infrastructure.

It was mandatory then, the separation of activities of the chain and the separation of the Enagás property was required (still under progress), bases for the economic and liquidations system were set and January 2005 was imposed as the deadline for the end of the grants in the distribution activity.

Furthermore, the concept of carriage sub-system stopped existing and the figure of the Technical System Management was created (*Empresa Nacional de Gas S/A, Enagás*). Distribution, transmission, re-gasification, underground storage and LNG storage facilities started to be subject to the free access for eligible consumers (GLOBAL, 2006).

Among the Enagas GTS responsibilities, therefore, there is the supply assurance level control, the forecast of the facilities' utilization and of the reserves and the system's reliability control.

Besides acting as the technical manager of the system, Enagas plays the role of leading company in the carriage, re-gasification and storage of natural gas in Spain: it owns approximately 7,600 km of high pressure gas pipelines system; three re-gasification plants (Barcelona, Cartagena and Huelva), with 4,050,000 m<sup>3</sup>/h full capacity; and it has 1,287,000 m<sup>3</sup> LNG full storage capacity.

It is important to mention that the development of the gas regulation in Spain followed the standard adopted in all the other integrating countries of the European Union and it tried to harmonize the national legislation both to the existing one and to that to be built by means of the European Community Directives. However, the permanence of specificities of each Country is certain.

The Spanish regulating agency of the energy sector is *Comisión Nacional de Energía (CNE)* initially subordinated to the *Ministerio de Economía*, current *Ministerio de Industria, Turismo e Comercio*. CNE is intended to zeal for the effective competition of the energy systems (electric, oil and natural gas market) and for the objectivity and transparency of its operation, in benefit of all the agents involved and of the consumers. In order to fulfill such objectives, extensive functions were attributed to CNE, acting also as a consultation agency in energy matters, both of the General State Administration, and of the Autonomous Communities (administrative divisions of the Spanish country).

CNE participates, along with government representatives, the Technical System Manager and the Autonomous Communities' representatives, in the process of planning the construction of facilities enabling the expansion of the Spanish gas system.

According to CNE, the next steps of the natural gas industry should go necessarily through: (a) a planning revision; (b) the development of the secondary natural gas markets; (c) the harmonization with the Directive rules; (d) other specific protocols of the Technical System Management Rules (NGTS) and the improvement thereof; and (v) the improvement in terms of transparency, flexibility, liquidity of the system, in the operation and management.

Regarding the facilities' safety, according to the information obtained during the technical visitations performed to the Sagunto and Barcelona Terminals, there are different studies and evaluations applied to each one of the development stages of a terminal: the design, the construction and the operation.

In the design stage, previous safety and HAZOP (Hazard and Operability Studies) are performed a mode examining systematically every segment of a facility, aiming to identify all possible offsets of the normal operation conditions, listing their causes and their consequences. During the construction state, standards ruling the installation of the terminal equipment are strictly complied with and the previous studies are revised. Finally, the operation safety is assured through the elaboration and application of procedures.

The Terminal of Sagunto also complies with the Directiva Seveso (Royal Ordinance no. 1254/1999), by means of which risk control measures inherent to severe accidents involving hazardous substances were approved. Such ordinance sets forth that the companies storing hazardous products should notify the authority of the Autonomous Community in which they are located as to their storage capacity, stored product rating, description of the technological processes and of the establishments around the plant, as well as of the elements which can cause a severe accident or aggravate the consequences thereof.

The Royal Ordinance 1254/1999 sets forth also that the institution should keep a Policy of Severe Accidents Prevention, in writing. Such policy should contain among other elements, the systematic adoption of procedures identifying and evaluating the risks of severe accidents and their consequences, and the adoption and application of procedures and instructions for the operation of the facilities, processes, equipment and stoppages in safe conditions and for the maintenance of such facilities.

Finally, during the technical visitation comments were made on the accomplishment of risk studies, which were based on the severity and the frequency for several accidents scenarios, and the nautical studies applicable to the Sagunto plant. The main purposes of those studies are the following: (a) checking and sizing the areas required for navigation and flotation; (b) establishing the limit conditions of the nautical operations; (c) evaluating the need of tugboats; and (d) identifying the nautical risks. It should also be worthy to advise that the responsible for the administration of the port of Sagunto as a whole is the Port Authority of the Valencia Autonomous Community.

## VII. RISKS RELATED TO THE LNG INDUSTRY

The LNG is obtained by the natural gas liquefaction process after treatment for removing impurities, such as water, nitrogen, carbon dioxide, hydrosulphuric gas and other sulphurized components. The removal of such components is made before the liquefaction process, once some may freeze in the natural gas dew point. Figure VII.1 shows the average natural gas and LNG compositions.

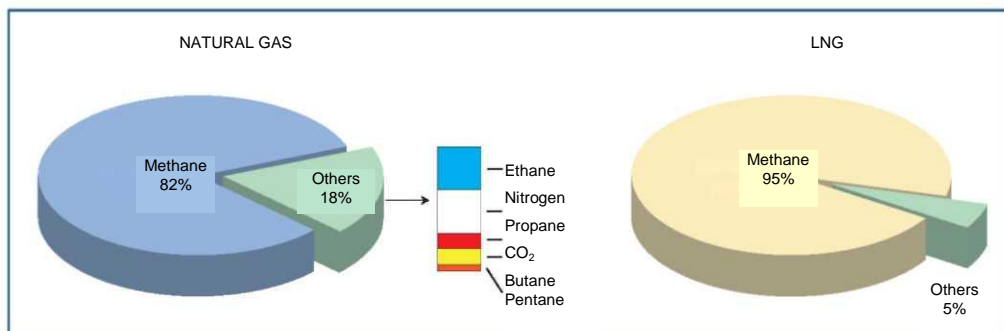


Figure VII.1 – Typical natural gas and LNG composition (Adapted from FOSS, M.M., 2007).

### VII.1. Risks inherent to the LNG

The LNG is stored only under refrigeration and not under pressure. Currently, mention is made to the product's pressurization, which implies in the mistaken evaluation of the risks related thereto. In fact, the currently employed technology as previously mentioned, makes

use of the product storage at atmospheric pressure and at a temperature of approximately -160° C.

The flammable vapors released as the LNG returns to the gas phase are only able to create an explosive atmosphere under set conditions. In order for the vapors to go through ignition, they should be within the flammability limit of the material, in that case, a mixture primarily comprised of methane. Thus, in order for the burn to occur, the methane-air mixture should contain 5% and 15% methane (Figure VII.2). Mixtures more concentrated in methane (above 15%) do not go through ignition for lack of oxygen, while with those with methane content below 5%, they do not go through it for lack of fuel.

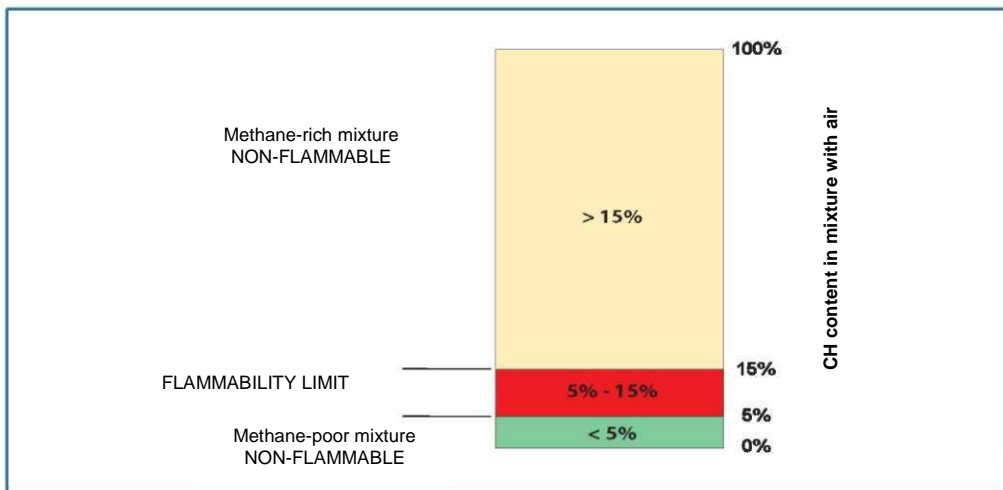


Figure VII.2 - Flammability limit of methane, the main component of LNG. (Adapted from FOSS, M.M., 2007).

The situation of an atmosphere excessively rich in combustible material occurs within the tanks where the gas phase is comprised almost totally by methane. In that situation, there is no possibility of fires by lack of oxygen. However, when there is a LNG leakage in ventilated areas, the vapors produced are mixed with air, and that may cause conditions that are suitable to fires, in case there is an external ignition source. However, the vapors are quickly dispersed in air, decreasing the concentration for values below 5%, which again, makes the fire possibility unfeasible. Thus, the higher ignition possibility occurs in points where there is a possibility of stagnation or in leakages in confined areas.

The LNG related risks result from its intrinsic properties, that is, of its flammable vapors, of low temperature and of the possibility of asphyxiation in leakages. As to the possible risks, one has (FOSS, M.M., 2003; FLYNN, T.M., 2005):



- **Explosion:** This phenomenon occurs when a substance suffers very quick reactions, such as the case of ignition, or it is released in an uncontrolled form under pressure. Since the LNG is not kept under pressure and the product plants normally count on prevention systems of the ignition sources the possibility of explosion is decreased.
- **Vapor clouds:** These are formed by the LNG vaporization with dispersion in the atmosphere. The cloud will only catch fire if it contacts an ignition source while it is within the flammability limits.
- **Freezing:** The human contact with LNG leads to freezing and burns and, therefore, all personnel involved should wear suitable personal protection equipment.
- **Rollover:** A convection phenomenon due to the LNG density differences. The movement may cause leakages through the PSVs and cracks in the tanks. This event may be easily prevented with the implementation of suitable operating procedures.
- **Asphyxia.** It is characterized with respiratory difficulty, with possible loss of consciousness due to the lack of oxygen. It may occur near the leakages location and in confined spaces where the persons are exposed to excessively high LNG vapor concentrations.

## VII.2. Main incidents

As compared to refineries and petrochemical plants, the LNG industry has an excellent history regarding the safety of the facilities. According to H.H. West and M.S. Mannan, of the Texas A&M University (FOSS, M.M., 2003):

“The worldwide LNG industry has compiled an enviable safety record based on diligent industry safety analysis and the development of appropriate industry safety regulations and standards”.

Over the last 40 years, LNG has been in fact moved by sea with safety. Within that period, more than 45 thousand travels were made by ship and approximately 100 million miles were navigated, without any severe accidents or safety problems occurring in the ports or offshore.

According to the Department of Energy of the United States, in 60 years of LNG industry, only eight incidents occurred worldwide in vessels with product leakage, and none of these resulted in fire. None of those leakages has occurred due to collisions or grounding of the vessels.

Some of the main accidents registered worldwide are listed in a summary form, below (FOSS, M.M., 2003; FOSS, M.M., 2007; CH-IV International, 2003; CH-IV International, 2006):

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### **a) Cleveland, Ohio, USA, 1944**

The accident occurred during the World War II in a peakshaving facility of the East Ohio Gas Company in 1941. That plant operated without incidents until 1944 when it was expanded in order to include a bigger tank.

Due to the war effort, there was a lack of steel alloys with high nickel content, a material suitable for manufacturing parts and facilities for operation in low temperatures. At that time, alloys with 9% nickel were used for building tanks for LNG storage. However, due to the lack of that material, steel with smaller nickel content, approximately 4%, was used instead. That material does not present suitable characteristics to works at low temperatures, having caused a LNG leakage with subsequent propagation of the gas cloud through the streets and penetration in the rain water system. The natural gas confined in the system suffered ignition, causing the death of 128 persons in the residential area adjacent to the plant.

The accident investigation was conducted by the U.S. Bureau of Mines, which concluded that the concept of liquefying and storing LNG is valid, provided that the suitable precautions are taken.

### **b) La Spezia, Liguria, Italy, 1971**

The event occurred in La Spezia was the first documented case of rollover in a LNG plant. The incident occurred after the discharge of the methane carrier ship Esso-Brega which was anchored in the port for approximately one month. After 18 hours discharging, the LNG tank of the terminal suffered a sudden pressure increase, which caused a gas leakage by the safety valves and by the vents<sup>13</sup> for a few hours. The tank roof was slightly damaged, although the ignition of the leaked product has not occurred. Subsequently, it was attributed to the LNG stratification the effect on the terminal storage tank, which caused the sudden movement of the tank contents and which caused the sudden pressure increase. That accident served as parameter for the elaboration of tank filling procedures, according to the temperature and density differences between the LNG stored in the tank and that of the current being supplied.

### **c) Staten Island, New York, USA, 1973**

The Staten Island accident occurred in a peakshaving facility of the Texas Eastern Transmission Company. The accident did not occur due to the LNG proper, but rather to problems during a tank's maintenance.

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<sup>12</sup> Peakshaving facilities are those including the liquefaction of natural gas and storage for subsequent re-gasification of the produced LNG, with the purpose of supplying the natural gas distributing companies in periods of high demand peaks.

<sup>13</sup> Tubular facility intended for releasing or relieving gas or steam.

In 1972, the operators suspected of a leakage in the tank and stopped the operation. The tank was emptied and during repairs, the combustion of the tank insulation occurred, which caused the displacement of its roof. The roof fall caused the death by crushing of 40 workers who worked inside the tank.

The New York Fire Department determined that the accident occurred clearly due to the works and not to the LNG.

#### **d) Cove Point, Maryland, USA, 1979**

In October 1979 there was a LNG leakage through the seal of one of the pumps in the Import Terminal Columbia Gas LNG Terminal. The gas cloud penetrated through a conduit and reached the terminal substation, causing explosion. The event caused the death of an operator.

The National Transportation Safety Board understood that the terminal was designed and built in compliance with the regulations and codes in force. Thus, as a result of the accident, changes were proposed in the codes of projects that are currently used all over the LNG industry.

#### **e) Skikda, Algeria, 2004**

In January 19, 2004 there was a leakage of the natural gas liquefying unit's cooling fluid. The released hydrocarbon formed a cloud that penetrated in the unit's boiler, increasing the quantity of fuel for burn. The increase in the amount of heat released caused a pressure increase in the system which exceeded the capacity of the safety valve and led to the boiler breakage. That facility was near enough of the area where the leakage occurred to cause the ignition of the steam cloud, which caused a fire ball. The fire killed 27 people and wounded 72. In the event, no LNG tank was damaged and no one outside the plant perimeter was injured.

Ferc and DOE of the United States attributed the accident to the existence of a nearby ignition source, lack of emergency stop devices and the lack of detectors in the fire and gas system.

According to what was mentioned above, it is concluded that the LNG industry has a high safety level, having evolved significantly with the learning resulting from the accidents. Except for the Cleveland accident (1944), all injuries caused by LNG occurred within the facilities' boundaries. It is highlighted that in the consulted reference, there is no record of fatalities in LNG carriage vessels and re-gasification.

## VIII. TECHNICAL CHARACTERISTICS OF THE IMPLEMENTED PROJECTS

The projects of the Guanabara Bay (RJ) and Pecém (CE) LNG Piers shown in Figures VIII.1 and VIII.2, following the same philosophy, had their descriptions grouped in item VIII.1 presented below. The main characteristics of the gas pipelines interconnecting each pier to the respective existing systems are described in item VIII.2. Finally, in item VIII.3, the main parameters used and the results obtained in the risk analysis of the projects performed by ABS Consulting are presented.



**Figure VIII.1** - Panoramic view of the Guanabara Bay LNG Project, showing the re-gasifying ship Golar Spirit, to the left of the supplying vessel.

**Figure VIII.2** - Panoramic view of the Pecém LNG Project, showing the re-gasifying ship Golar Spirit, to the left of the supplying vessel (Source: Petrobras).

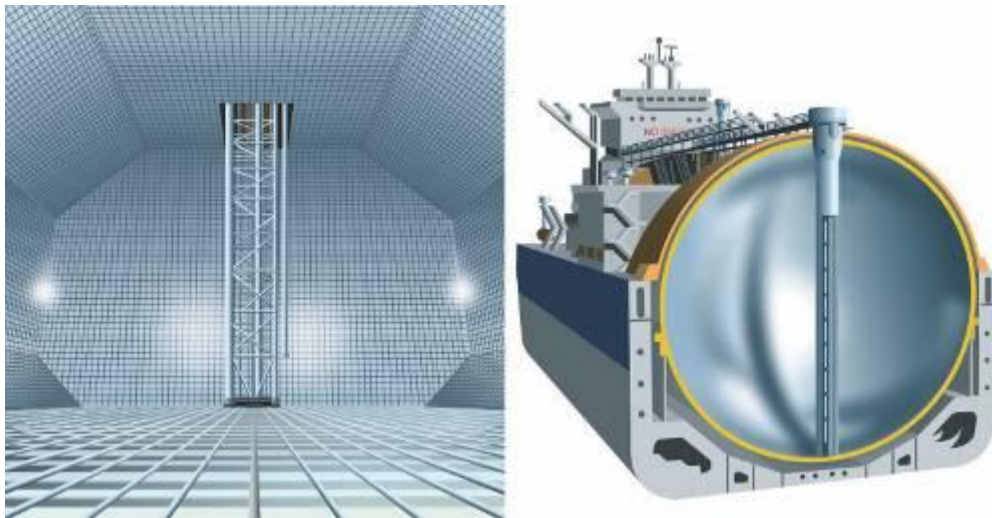
### VIII.1. Description of the Piers' facilities

The project of the Pecém (CE) and Guanabara Bay (RJ) LNG Piers comprises the LNG and natural gas transfer facilities, as well as gas pipelines interconnecting such facilities to the natural gas carriage system. The LNG project of Pecém was performed on the Pier 2 of the Port of Pecém, which was previously used for the movement of liquefied petroleum byproducts. As to the Guanabara Bay project, it has involved the construction of a new pier located near the Guanabara Bay Waterway Terminal (TABG).

Each Pier has two berths, one designed to allow the mooring of LNG supplying ships, and the other for re-gasifying ships (VT). In the mooring berth of the supplying ships there are three arms: two for unloading LNG and one for vapor return. The other berth counts on five unloading arms, three for the LNG transfer operations among ships and two for unloading the natural gas obtained by the ship's LNG re-gasification.

The ships freighted by Petrobras as re-gasifying ships in such projects were originally used for the carriage of LNG and they have gone through adaptations to incorporate the re-gasification plants. The ship Golar Spirit has a capacity to gasify 7 million m<sup>3</sup>/day and to store 129,000 m<sup>3</sup> LNG, which is equivalent to approximately 77.4 million m<sup>3</sup> gas (@ 1 atm and 20°C). That ship was freighted for the period of ten years and it was intended to stay moored in the Port of Pecém. As to the Golar Winter, it was freighted to remain at the Guanabara Bay having a storage capacity of 138,000 m<sup>3</sup> LNG, which is equivalent to approximately 82.8 million m<sup>3</sup> gas (@ 1 atm and 20 °C). The re-gasification plant in that ship has a capacity to generate 14 million m<sup>3</sup>/gas a day.

The two ships differ by their storage and re-gasification capacities and by the used storage tank types, namely: Moss type for the Golar Spirit and membrane type for the Golar Winter (Figure VIII.3).



**Figure VIII.3** – Storage tanks of the LNG ships freighted by Petrobras: (a) Membrane type tank – Golar Winter, and (b) Moss type tank – Golar Spirit (ABS CONSULTING, 2007; FOSS, M.M., 2003).

Figure VIII.4 shows the flows involved in the LNG transfer and of natural gas (NG) movement processes. The LNG transfer arms were denominated by TAG as numbers 1 to 6 and those to transfer re-gasified natural gas by the numbers 7 and 8.

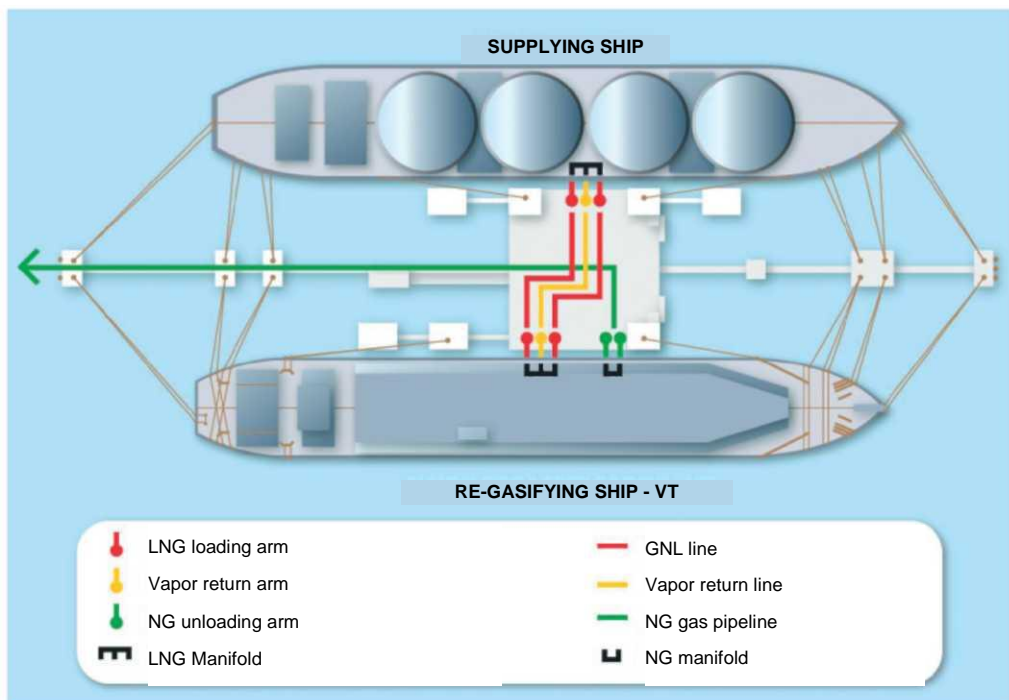


Figure VIII.4 – Scheme of the flows involved in the LNG Project (Adapted from ABS CONSULTING, 2007)

The LNG transfer operation was sized for a maximum 10 m<sup>3</sup>/h flow by the arms numbers 1 to 6 and by the cryogenic pipelines, being used in such occasions, the supplying ships' pumps.

The loading arms are provided with a QCDC (quick connect/disconnect couple) hydraulic mechanism for the connection to the manifolds of the supplying and VT vessels. Those connectors are part of the Emergency Shutdown System – ESD and they can be manually or automatically disconnected. The system is activated when there is a leakage or when the ship sails beyond the limits of the arms' operation envelope, thus minimizing the LNG spill.

The LNG transfer lines interconnecting the unloading/loading arms installed in the supplying/VT ships' berths are 16" in outer diameter and were made in stainless steel suitable to the low temperatures involved. Those lines were thermally isolated with foam glass or with expanded polyurethane depending on the location, and protected from mechanic damages and bad weather by aluminum plates placed on the isolation.

once the LNG is received, the VT ship promotes the liquid re-gasification, in order to obtain the natural gas which, by means of the arms numbers 7 and 8, is high-pressure unloaded and sent to the pier, with the subsequent injection in the gas pipelines' system. Those arms are also provided with a QCDC system aiming to minimize leakages. The arrangement of the arms in the pier, as well as with all the other auxiliary facilities, is shown in Figure VIII.5.

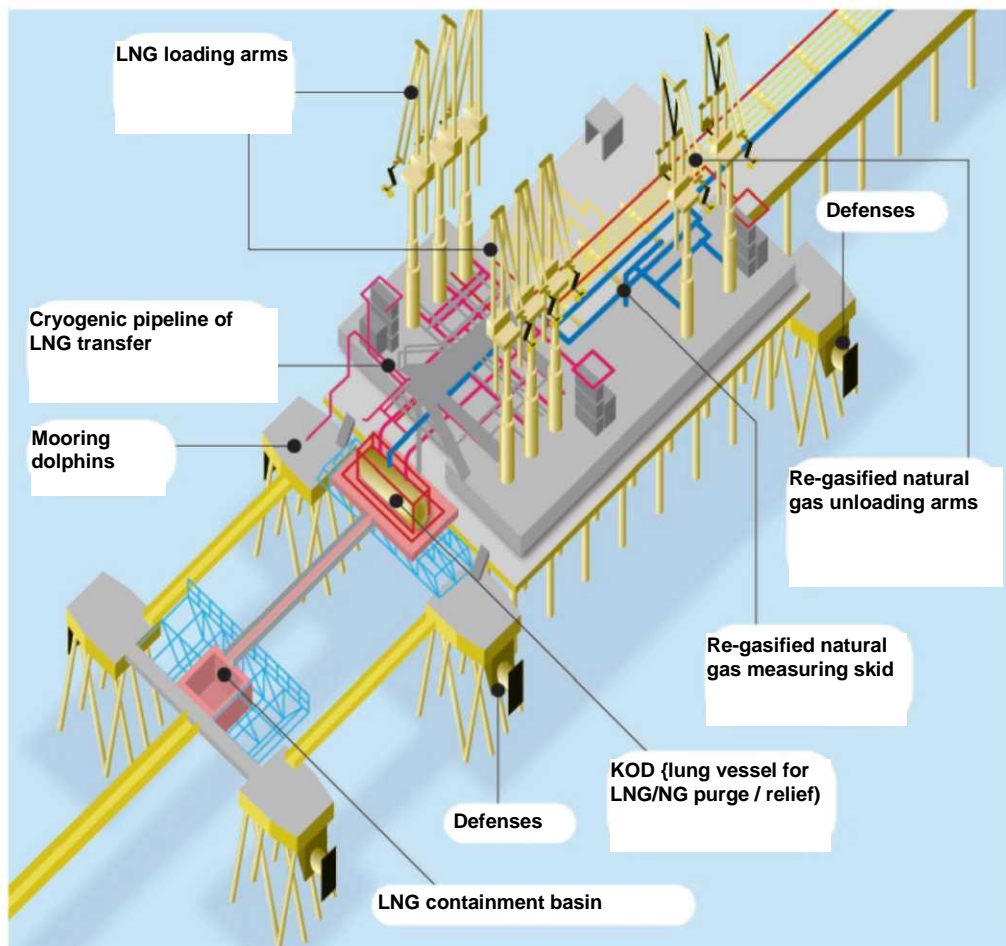


Figure VIII.5 – Arrangement of the facilities in the LNG piers (Adapted from EMCOHITRAX ENGINEERING, 2008).

Those auxiliary systems comprise, among others, hydraulic units and arms' accumulators, drainage systems, electric substation, nitrogen system, firefighting system and control room. A summary description of some of those systems is presented below:

- a) **Hydraulic units and accumulators:** These are responsible for the driving of the LNG and NG loading/unloading arms.
- b) **Electric substation:** The electric power used in the LNG piers is supplied by the public power companies by means of two 13.8 kV independent lines. In the substation, the input voltage is reduced and distributed to the industrial area and to the control room. The emergency supply is made by a diesel generator, and there are also battery systems (UPSs) for the critical instrumentation, emergency lights and PLCs (Programmable Logic Controllers).
- c) **Nitrogen system:** This system is installed in a container and is comprised of compressors and membranes for separating nitrogen from air. It supplies all nitrogen required for the plant's operation, where it is used to seal the rotating joints of the LNG transfer arms, for the arms' purge and drainage, lines and Knockout Drum (KOD).

- d) Drainage system:** The rain waters and discharged LNG drainage is made by means of a system of gutters directing the fluids to an impoundment area located at the end of both piers. A level sensor shows the water accumulation inside that basin which, by means of pumps, is disposed of. It is necessary to always check this procedure, since the presence of water during the LNG transfer should be prevented for being able to cause the quick vaporization of this product, a phenomenon known as Rapid Phase Transition (RPT).
- e) Knockout drum, KOD:** The purge of all LNG lines and vapor return lines is directed towards this drum. Once the LNG transfer is ended, or when a certain volume of liquid is reached inside the vessel, the product is discharged to the VT ship. In case de vapor pressure reaches the maximum acceptable level, the vessel safety valve opens, sending gas to vent.
- f) Vent:** The system has two lines: one high pressure line (from the NG system coming from the LNG re-gasification) and a low pressure line (coming from the KOD). Both lines are provided with nitrogen injection in the upper end, in order to prevent the formation of an explosive atmosphere, and retention valves to stop the air from penetrating.
- g) Control room:** PLC's with Scada (Supervisory Control and Data Acquisition), operated by Transpetro were installed in the control room, allowing the accomplishment and remote supervision of all pier operations. The emergency systems of the supplying vessel and the VT ship are connected to the pier supervisory system through the ship-to-shore link, provided with alarms alerting the operators as to the need of actuating the emergency shutdown system (ESD). This system also works as a data transmitter (ship-to-shore data communication link, or SSL).
- h) Measuring station and chromatograph:** the NG Measurement Station (Emed), the chromatograph, the blocking valves and the instrumentation are all connected to the control room PLC's, which transfer the data by means of the RIC (Individual Cable System) and VSAT (Very Small Aperture Terminal) systems to Transpetro's National Operating Control Center (CNCO) located in Rio de Janeiro.
- i) Firefighting system:** Both piers use sea water in their systems. The area of each pier is covered by two monitoring guns, installed in towers using chemical dust for firefighting LNG puddles and jets. The piers also count on foam systems in the containment basins and in the KOD region, which are used to decrease the LNG evaporation rate during spills. Water sprinklers are also installed in selected areas to cool certain equipment when in flames or exposed to radiation. Additionally, the piers are provided with a hydrant system and portable extinguishers strategically distributed. The water supply to the Guanabara Bay Pier is made from the fire pump station of Ilha Redonda. Located approximately 2,800 m away, the station was modernized in order to supply the new demand of the Pier.



The pier fire system is kept pressurized by means of a hydro-pneumatic vessel (pressure tank containing air and water) located in that island. Project Pecém also contemplated the modernization of the pump house already existing in the pier, which currently counts on two main pumps with 240 m<sup>3</sup>/h capacity each, besides the installation of a new pump yard with two main pumps of the same capacity and two Jockey pumps used to keep the system pressurized. The firefighting system was sized according to the Standards NFPA-15 and NFPA-11.

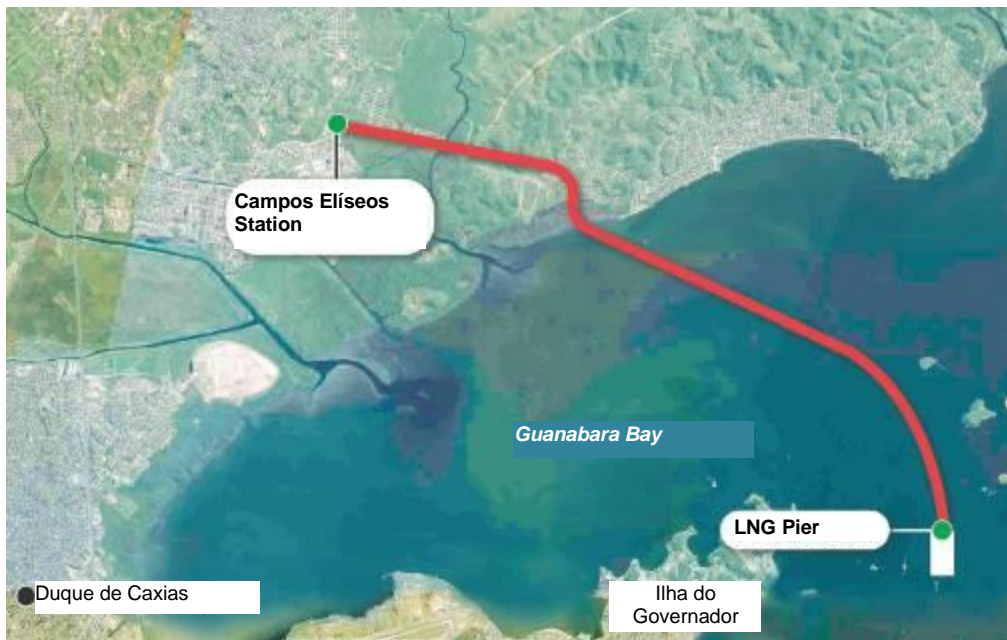
**j) Mooring system:** This system is comprised by mooring dolphins and defenses. In the mooring dolphins, bitts provided with quick release hooks were installed allowing releasing the moorings in case the tension is too high. Load cells, connected to the mooring hooks, allow monitoring the tensions of each mooring, in real time, from the control room. This system allows the pier operators to contact the ships so that their crew make the required adjustments, in order to assure that the tension in the moorings is kept within the safe operation range.

**k) Mooring monitoring system:** The system provides information on the distance and approximation speed of the ships in real time, in the critical zone 0 to 300 m from the pier. With such information, the captain and the pilot direct the tugboats to a safe maneuver, thus minimizing potential damages to the berths or to the ships.

## VIII.2. Description of the gas pipelines

The natural gas from the LNG re-gasification in the VT ships is transferred to the existing system by means of gas pipelines interconnecting the Guanabara Bay and Pecém piers to the Campos Elíseos and MPX Filtration Stations, respectively.

The gas pipeline of the Guanabara Bay project with 28" diameter and approximately 16 km long, is comprised of two segments, being one submarine and the other terrestrial (Figure VIII.6). The submarine segment, approximately 10 km long, connects the pier located at the end of the navigation canal in Guanabara Bay, to the Mauá Beach. In the transition between the sea stretch and the land stretch, an automatic blocking valve is installed (SDV-02) and a vent used to depressurize the gas pipeline, in the stretch from the pier to Mauá Beach, in an emergency situation. The land stretch of the gas pipeline starts at the point of arrival of the sea pipeline, close to the city of Magé, goes towards Northwest for approximately 2 km in a new lane, until it reaches the existing lane of the pipelines interconnecting the Cabiúnas Station to Reduc. The gas pipeline goes by the existing lane for approximately 3 km until it reaches the Campos Elíseos Station. In the land part, the municipalities of Magé and Duque de Caxias are crossed. A pig receiver and an operating measurement station were installed in the Campos Elíseos Station. The pipeline operating conditions are included in Table VIII.1.



**Figure VIII.6** – Layout of the gas pipeline interconnecting the LNG Guanabara Bay Pier to the Campos Elíseos Station. (ABS CONSULTING, 2007).

The LNG Project gas pipeline in the Port of Pecém is approximately 19.1 km long and 20” nominal diameter. This gas pipeline interconnects Pier 2 of the Port of Pecém to the MPX Filtering Station, and there is also a connection to the Pecém Delivery Point. The land stretch of the gas pipeline crosses the municipalities of São Gonçalo do Amarante and Caucaia. Figure VII.7 highlights the pier installation areas in red, the air gas pipeline layout in blue and the pig launcher region in green. The pig receiver is installed in the MPX Filtering Station. The main gas pipeline process variables are presented in Table VIII.1.



**Figure VIII.7** - Layout of the gas pipeline interconnecting the Pecém LNG Pier to the MPX Filtration Station. Captions: red ellipsis: pier; blue line: air gas pipeline layout; and green ellipsis: pig launcher (Adapted from GALVÃO ENGENHARIA, 2008).

**Table VIII.1** - Operation conditions of the gas pipelines.

Conditions		Pecém	Guanabara Bay
<b>General</b>	Fluid	Natural gas	Natural gas
<b>Flow rate (x10<sup>6</sup> m<sup>3</sup>/day)</b>	Normal	1.0 - 7.0	1.5 - 14.0
	Max.	7.0	20.0
	Min.	1.0	1.5
<b>Pressure (kgf/cm<sup>2</sup>)</b>	Normal	58 - 100	58 - 100
	Max.	100	100
	Project	100	100
<b>Temperature (°C)</b>	Operation	5 - 20	4.3 - 27.6
	Project (min/max)	0/55	0/55

### VIII.3. Gas supply

The LNG Projects were conceived with the main purpose of supplying thermal-electric power stations in low level occasions of the hydric reservoirs related to the hydro-electric power stations. The supply capacities of the Pecém and Guanabara Bay Projects are discriminated in Table VIII.2.

**Table VIII.2** - Characteristics of natural gas supply from the LNG piers.

	Pecém	Guanabara Bay
Re-gasifying ship	Golar Spirit	Golar Winter
Ship's re-gasification capacity	7 million m <sup>3</sup> /day	14 million m <sup>3</sup> /day
Operation pressure of the related gas pipeline	100 kgf/cm <sup>2</sup>	100 kgf/cm <sup>2</sup>
Capacity of the related gas pipeline	7 million m <sup>3</sup> /day	20 million m <sup>3</sup> /day
Number of days of gas supply from the ship <sup>a</sup>	12 days	6 days
Thermal power stations that can be supplied by the projects <sup>b</sup>	- Termofortaleza (311MW); - Termo Ceará (218 MW); - Termo açu (340MW).	- Governador Leonel Brizola (Termorio – 1.060MW); - Barbosa Lima Sobrinho (Eletrobolt – 386MW); - Santa Cruz (766MW);

<sup>a</sup> Considering the full re-gasification capacity of the ship.

<sup>b</sup> The capacities shown between brackets refer to the maximum generation of each power station.

### VIII.4. Risk analysis of the projects

ABS Consulting performed quantitative risk analyses of the Pecém and Guanabara Bay LNG piers (ABS CONSULTING, 2007 ,b), intending to estimate the risk introduced to the neighboring populations as a result of the future operation of the facilities. This study adopted the premises of the codes and recommendations of the foreign standards as to the exposure to the LNG plants, such as: Code of Federal Regulations (CFR), National Fire Protection Agency (NFPA) e Society of International Gas Tanker and Terminal Operator LTD (SIGTTO). For such, the possible scenarios of accidents involving LNG were identified and analyzed to help Petrobras identifying the dangers related to the facility and develop an effective Risk Management Program.

The HAZID (Hazard Identification) technique was used, which is a qualitative methodology intended to identify and rate the dangers which may cause damage to people, to the facilities or to the environment. The causes, the consequences, the severity categories, the scenarios' frequency categories and the risk rating are identified, and also the applicable recommendations are surveyed.

The qualitative evaluation of the risks related to the identified hazards was conducted according to the provision in standard N-2782 – “Criteria for the Application of Risk Evaluation Techniques” identifying the occurrence frequency categories and the severity of the consequences. However, Petrobras' experts have made changes in the severity categories, with the intention of adapting the standard to the LNG study.

Risk matrixes were assembled in which four consequences categories were taken into account (negligible, marginal, critical and catastrophic), five frequencies categories (extremely remote, remote, unlikely, likely and frequent), and three risk categories (non-critical, moderate and critical). Such categories are presented in Tables VIII.1 to VIII.3 below.

**Table VIII.1 – Criteria for managing risks (ABS CONSULTING, 2007a,b).**

Category	Description
Non-critical (NC)	The risk is acceptable. There is no need of additional measures.
Moderate (M)	The risk is deemed acceptable when it is kept under control. Additional controls should be evaluated and implemented applying an analysis for evaluating the available alternatives, in order to obtain an additional reduction of the risks.
Critical (C)	The risk is deemed unacceptable with existing controls. Alternative methods should be considered to decrease the likeliness of occurrence and additionally, the consequences.

**Table VIII.2 – Categories of occurrence frequency (ABS CONSULTING, 2007a,b).**

Category		Frequency
A	Extremely remote	< 1 in 10 <sup>6</sup> years
B	Remote	1 in 10 <sup>4</sup> to 10 <sup>6</sup> years
C	Unlikely	1 in 10 <sup>2</sup> to 10 <sup>4</sup> years
D	Likely	1 per year to 10 <sup>2</sup> years
E	Frequent	> 1 per year

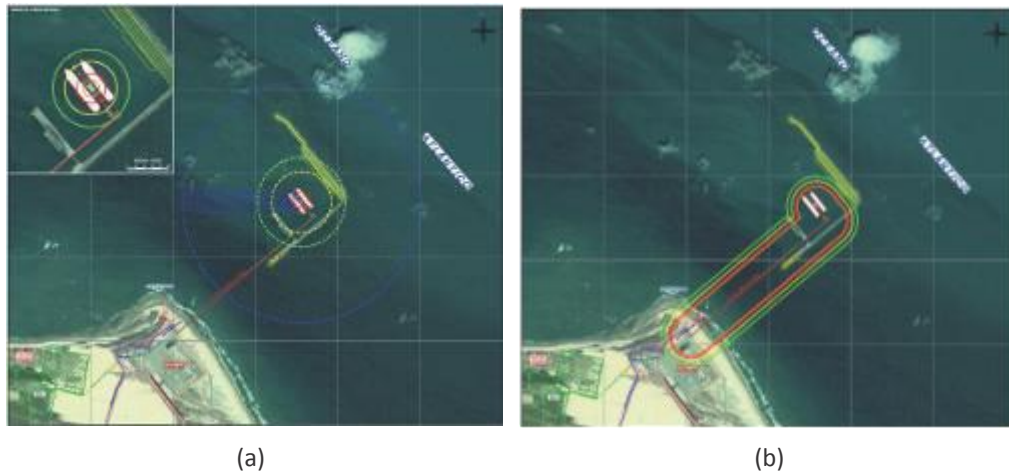
**Table VIII.3 - Categories of consequence severity (ABS CONSULTING, 2007a,b).**

Description	Severity Categories			
	I – Negligible	II – Marginal	III – Critical	IV – Catastrophic
External Safety (Public)	There are no injuries/deaths of persons outside the limits	Light injuries in persons outside the limits	Moderate severity injuries in persons outside the limits	Causes death in persons outside the limits
Environment	No likely damages to the environment	Possible damages to the environment due to direct emissions of up to 8 m <sup>3</sup> oil in water bodies	Possible damages to the environment due to direct emissions from 8 m <sup>3</sup> to 200 m <sup>3</sup> of oil in water bodies	Possible damages to the environment due to direct emissions higher than 200 m <sup>3</sup> of oil in water bodies

The frequencies of the accidental scenarios were determined based on the information from data bases and on the experience of the professionals who attended the HAZID.

### VIII.4.1. Results of the Pecém HAZID

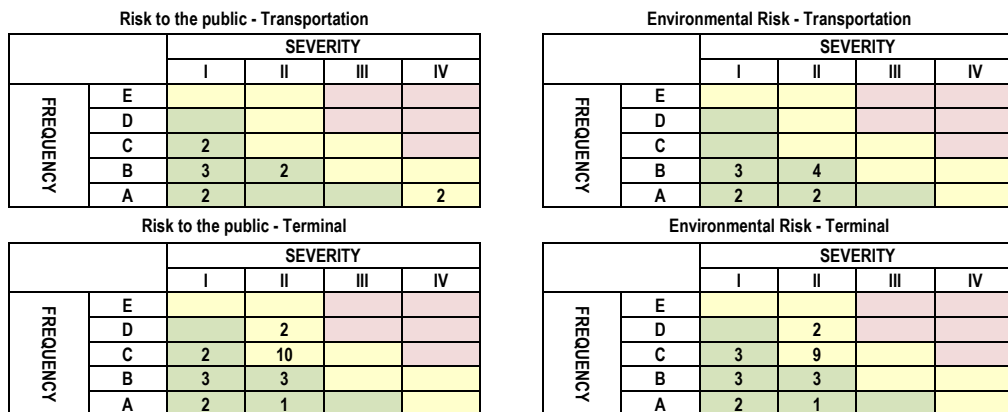
The worst case identified for the Pecém LNG Pier was a daytime event involving the rupture of one of the LNG unloading arms. For that case, the vapor cloud could reach 1,400 km from the rupture point, as shown in Figure VIII.8a. Additionally, it was detected that the worst case for the gas pipeline would be a nighttime leakage near the pier, which would reach the area shown in Figure VIII.8b.



**Figure VIII.8** - Results of the leakage models for the worst cases identified in the Pecém LNG Project: (a) Pier and (b) Gas pipeline.

The events' frequency analysis versus severity, presented in Figure VIII.9 shows that all identified risks fit in the non-critical and moderate categories. ABS Consulting states:

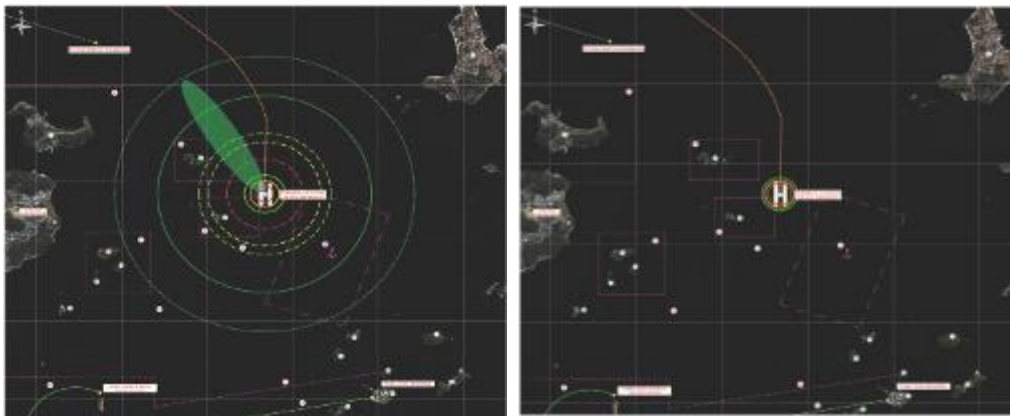
“None of the events evaluated in this risk analysis for Flexible Terminal of the Port of Pecém proposed by PETROBRAS, presented unacceptable risk to the population’s safety; or why such events were deemed non-critical, or why, when credible, they presented CONSEQUENCES the vulnerable distances of which do not reach the nearest population (the Flexible Terminal is located approximately 3,200 m from the Vila de Pecém).” (ABS CONSULTING, 2007a)



**Figure VIII.9** – Risk matrixes of the Pecém LNG project (ABS CONSULTING, 2007a).

## VIII.4.2. Results of the Guanabara Bay HAZID

The worst case for the Guanabara Bay LNG Pier involves the LNG leakage as a result of a failure in the emergency system, with subsequent delayed ignition and consequent fire in cloud. In that case, the flammable concentration would have a reach of 1,750 m from the pier (Figure VIII.10a). The effect of a leakage or a rupture in one of the lines of natural gas obtained from the LNG re-gasification was also evaluated, in the region of the pier where the measurement station and the pig launcher are located, during the gas injection in the Southwest Network. The impact of such leakage is illustrated in Figure VIII.10b. It should be pointed out that in none of the analyzed cases, the flammability zone reaches any inhabited region.



**Figure VIII.10** - Results of the leakage models identified in the Guanabara Bay LNG Project: (a) LNG leakage in the arms and (b) NG leakage in the lines on the pier.

The analysis of the events frequency versus severity presented in Figure VIII.11 shows that all risks identified fit in the non-critical and moderate category, being stated by ABS Consulting that:

“The evaluated events presented acceptable risk for the population safety; or because such events were deemed non-credible or because when credible, they presented consequences the vulnerable distances of which (smaller than 1,750 m) do not reach the population in the nearest islands (the Terminal is located approximately 2,400 m from Ilha do Governador, 2,300 m from the Ilha de Paqueta and 1,820 m from Ilha Rijo).” (ABS CONSULTING, 2007b)

		SEVERITY			
		I	II	III	IV
FREQUENCY	E				
	D				
	C	2			
	B	4	3	1	
	A	2			2

**Risk to the public - Transportation**

		SEVERITY			
		I	II	III	IV
FREQUENCY	E				
	D				
	C				
	B	4	4		
	A	2	2		

**Environmental Risk - Transportation**

		SEVERITY			
		I	II	III	IV
FREQUENCY	E				
	D		2		
	C	1	10		
	B	2	4		
	A	2	1		

**Risk to the public - Terminal**

		SEVERITY			
		I	II	III	IV
FREQUENCY	E				
	D		2		
	C	2	11		
	B	3	2		
	A	2	1		

**Environmental Risk - Terminal**

**Figure VIII.11** - Risk matrixes of the Guanabara Bay LNG project (ABS CONSULTING, 2007b).

## **IX. THE PROCESSES OF PREPARING DECLARATIONS OF PUBLIC INTEREST AND ISSUED AUTHORIZATIONS**

In November 21 2006, the Brazilian National Council for Energy Policy (CNPE) issued the Resolution CNPE no. 4 which established the directives and recommendations for the implantation of LNG import projects, in order to assure a reliable, safe and diversified supply of natural gas. Based on such resolution, published in *Diário Oficial da União* of 11/24/2006, TAG presented to ANP in the second quarter of 2007 two projects for building LNG receiving facilities and for outflow of the natural gas obtained from the re-gasification of that product.

Soon after, Petrobras in the capacity of TAG controller requested the Agency to arrange the instruction of the public interest declaration ordinances, for the purposes of expropriation, of the areas required for the implantation of the natural gas outflow pipelines.

The procedure used by that Agency to continue the processes and the legislation in which ANP was based upon are described in sub items IX.1 and IX.2 below.

### **IX.1. Preparation of the public interest ordinances**

Art 8, clause VIII of Law 9.478 (Law of Oil) of August 6, 1997, sets forth that:

“ANP is in charge of preparing a process aiming the public interest declaration, for the purposes of expropriation and institution of administrative easement, of the areas required for exploitation, development and production of oil and natural gas, construction of refineries, pipelines and terminals”.

Since the mentioned clause was not regulated until now, the Superintendence of Commercialization and Movement of Oil, By-products and Natural Gas (SCM) of ANP established that in order to prepare LNG processes, the following documents should be forwarded to the Agency:

1. Macro-location plan of the undertaking, as well as plans allowing the visualization of crossings, accessories facilities and related access areas;
2. Geographic coordinates table of the pipeline and the support areas layout (valves, accesses, etc. area), the direction and distance followed point-to-point and the municipalities where each pair of coordinates are found;
3. Minutes of the ordinance that would be published containing the coordinates, the pipeline length, the band width, the dimension of the land areas required for the implantation of the undertaking, as well as the change in the municipalities and the first crossings involved;
4. Project’s description log;
5. Minutes of the process forwarding official letter by ANP, to the Brazilian Ministry of Mines and Energy;
6. Minutes of the exposé of reasons of the Brazilian Ministry of Mines and Energy to the President of the Republic; and
7. Previous license of the environmental agency responsible for the licensing, liberating the undertaking location.

The documentation would be evaluated by ANP's SCM which after evidencing the documents' compliance would submit the process to the legal review of the General Agency Attorneyship. Once the legal requirements are met, the instruction would follow to the appreciation by the ANP Board of Directors, and then to the Brazilian Ministry of Mines and Energy (MME), and next, it would be forwarded to the president of the Republic.

In that context, in October 5, 2007 Petrobras requested ANP to prepare the public interest declaration process, for the purposes of expropriation or administrative easement of the areas intended for the construction of the land part of the gas pipeline interconnecting the Guanabara Bay LNG Pier to the Campos Elíseos Station (LNG Pier - Campos Elíseos Gas pipeline). The regions at issue are located in the municipalities of Magé and Duque de Caxias (RJ) with an approximate distance of 5 km and 565 thousand square meters area.

In October 15, 2007 Petrobras requested the preparation of the public interest declaration process from the region intended for the construction of the Porto de Pecém – Gasfor gas pipeline, in the municipality of São Gonçalo do Amarante (CE), with an approximate length of 6 km. That pipeline stretch has an approximate area of 294 thousand square meters.

After the process of analysis, technical evaluation and legal evaluation of the required documents, ANP forwarded the Guanabara Bay and Pecém processes to the MME in December 3 and 4, 2007, respectively. In January 7, 2008 the President of the Republic declared the private property terrains and improvements required for the construction of the gas pipelines of the two LNG projects, Porto de Pecém – Gasfor and the Guanabara Bay – Campos Elíseos LNG Pier as being of public interest for the purposes of total or partial expropriation, or institution of administrative easement, on behalf of Petrobras. The ordinances of the President of the Republic were published on January 8, 2008 in Section 1 of Diário Oficial da União.

Four months later, on May 7, 2008 Petrobras requested the change of the gas LNG Pier-Campos Elíseos pipeline layout for having evidenced interference with the original layout requested with a land allotment intended for the construction of an industrial complex, the project of which had been approved by the City Hall of Magé (RJ). Once the layout change was evaluated, the documents were forwarded again to the MME in August 5 of that year, with subsequent publication of the Presidential Ordinance of 12/28/2008 in Diário Oficial da União of 12/30/2008.

## **IX.2. Authorization granting**

The authorization granting processes of the LNG processes were started on August 21, 2007 when TAG requested authorization for construction and implantation, in Pier 2 of the Port of Pecém, the facilities intended to move LNG and the natural gas coming from its re-gasification, as well as for the gas pipeline that would interconnect the Pier to the MPX Filtration Station.

In October 8, 2007 the company forwarded to ANP a new construction authorization request for a LNG Project, this time for a pier that would be built in Guanabara Bay, along with the gas pipeline that would interconnect that facility to the Campos Elíseos Station.



## **IX.2.1. Relevant legislation**

Since the authorization requests of construction and operation of the LNG projects' facilities were made on a date before the issuing of Law no. 11.909/2009 (Law of Gas), ANP resorted to the regulatory instruments in force then – the Law no. 9.478/1997 (Law of Oil) and Ordinance ANP no. 170/1998, the relevant aspects of which are described in the items below.

### **IX.2.1.1. The Law of Oil**

Law 9.478/1997 sets forth in its Art. 56 that companies incorporated under the Brazilian laws having their headquarters in the Country, may receive authorization from ANP to build facilities and perform any carriage mode of oil, its byproducts and natural gas, either for domestic supply or for import and export. However, Art. 65 of the same Law determines that Petrobras constitutes a subsidiary company with specific attributions of operating and building its pipelines, sea terminals and vessels for carrying oil, its byproducts and natural gas. In compliance with this article, Petrobras created the whole-owned subsidiaries Transpetro and TAG.

### **IX.2.1.2. Ordinance ANP no. 170/1998**

Based on Ordinance ANP no. 170/1998, “establishing the regulation for building, expanding and operating the carriage or transfer facilities of oil, its byproducts, natural gas, including liquefied gas, biodiesel and diesel oil/biodiesel mixtures” (highlighted by the authors), TAG requested ANP in the second semester of 2007 to give authorization for the construction of the facilities integrating the LNG projects.

The construction authorization request came from TAG, a company the social object of which is the activity of natural gas carriage because, according to Art. 6 of Ordinance ANP no. 170/1998 “in case ANP rates the facilities as being natural gas carriage, the authorization shall only be granted to a legal entity the social object of which contemplates, solely the activity of construction and operation of the carriage facilities” (highlighted by the authors).

#### **a) Construction authorization**

Articles 3 and 4 of ANP Ordinance no. 170/1998 deal specifically with the documentation required for the construction authorization granting for carriage and/or transfer facilities:

“Art. 3. The construction authorization request (AC) shall be forwarded to ANP instructed with the following information:

- I - Articles of incorporation, statutes, or bylaws in force, duly recorded in the Commercial Board, when dealing with commercial corporations, and in the case of joint stock companies, followed up by election documents of their managers or directors;

- II - Evidence of registration in the Federal and State Treasuries;
- III - Summary of the facility project, presenting the intended service, the movement and storage capacities discriminated for each step of the project implantation, besides the basic technical data relevant for each type of facility;
- IV - Preliminary plan or scheme of the facilities;
- V - Physical-financial timeline of the undertaking implantation;
- VI - Installation License (LI) issued by the relevant environmental agency.

Art. 4. ANP shall review the documentation presented by the requesting company within the maximum term of ninety (90) days counting from the date of its delivery.

Sole paragraph: ANP may request from the concerned party additional information and, in that case, the term mentioned in the caput hereof starts to be counted from the date of delivery of that information.”

Besides, Art. 5 of the Ordinance sets forth the requirement that publicity is given to the intended projects. For such, the project summary should be published in *Diário Oficial da União*, for the opening for comments and suggestions during thirty (30) days.

## **b) Operation authorization**

Once the facilities’ construction is ended, the regulated agent should request from ANP the Operation Authorization, in the terms of Art. 9 of Ordinance ANP no. 170/1998:

“Art. 9. The Operation Authorization (AO) request shall be forwarded to ANP, containing the following documentation:

- I - Operation License (LO) issued by the relevant environmental agency;
- II - Works Commissioning Certificate issued by a specialized technical entity, a corporation independent of the requesting company, focusing the facilities’ safety and certifying that the same were built according to suitable technical standards;
- III – “Maintenance Plan Summary of the carriage facilities and of the Quality Assurance System for the operation stage”.

ANP may request additionally the forwarding of any other information it deems necessary to grant this Authorization, as provided for in the sole paragraph of Art. 10 in the Ordinance:

“Art. 10. (...) Sole paragraph: ANP may request additional information and, in that case, the term mentioned in the caput hereof shall start to be counted on the delivery date of such information in the Agency.”

### IX.3. The ANP Work Group for the LNG

In order for a facility to receive an authorization from ANP, the project of such facility should be forwarded to the organizational unit of the Agency responsible for the facility type, in case the Superintendence of Commercialization and Movement of Oil, its Byproducts and Natural Gas (SCM). The unit analyses the project, based on the relevant legislation, and issues a Technical Opinion. The General Attorneyship of ANP reviews this opinion from the legal point of view, along with a draft of the intended authorization. Then the process goes to the Collegiate Board, for analysis and deliberation.

However, this process may be changed when the Collegiate Board grants to the titleholder of a certain organizational unit of ANP a delegation of competence. The delegation allows who receives it to practice the administrative acts and forward its decisions directly to the ANP Executive Secretariat, which arranges the publication in *Diário Oficial da União*. With such spirits, the Ordinance ANP no. 206 of 9/9/2004 delegated to the SCM superintendent powers to, among other administrative acts, publish summary and granting of construction and operation authorizations for the facilities contemplated in Ordinance ANP no. 170/1998. Thus, the summaries of the Pecém and Guanabara Bay LNG projects were published on 10/16/2007 and on 11/7/2007 respectively.

During the analysis of the documentation for granting the construction authorities, the SCM superintendent deemed necessary and recommendable, given the originality and the complexity of the projects, the interaction of the area with other Agency's organizational units by building a Work Group (WG)<sup>14</sup>. After the creation of such WG, the SCM superintendent dispensed with its competence delegation. Thus, the decisions on the processes returned to the hands of the ANP Collegiate Board.

Aiming to gather knowledge and experiences of several areas and to assure the integrity and safe operation of the facilities, the Work Group was comprised of professionals from the following areas:

- Superintendence of Commercialization and Movement of Oil, its Byproducts and Natural Gas (SCM) in charge of coordinating the WG and managing the project analysis;
- Superintendence of Biofuels and of Product Quality (SBQ);
- Superintendence of Development and Production (SDP);
- Superintendence of Natural Gas Refining and Processing (SRP);
- Coordination of Environment (CMA);
- Coordination of Operating Safety (CSO).

The WG Technical Opinions were founded on the decisions of the ANP Collegiate Board as to the granting of construction and operation authorizations of the projects.

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<sup>14</sup> The WG was created by Ordinance ANP no. 217, of 11/30/2007.

## **IX.4. The granting of authorizations for the LNG projects**

### **IX.4.1. Summary Publication**

Following the provision in Ordinance ANP no. 170/1998 when TAG registered the requests for the construction of the Pecém and Guanabara Bay LNG Piers in the second semester of 2007, the process of granting the authorizations was started with the publication of the summaries.

The summaries were published before the WG creation, by means of the Competence Delegation Record. The Superintendent Dispatches no. 1.011 of 10/15/2007, and no. 1.099 of 11/06/2007 were published referring to the Pecém and Guanabara Bay projects, respectively.

For the publications, TAG forwarded a description log of the conceptual project and some drawings of the basic project of each undertaking. ANP has identified inconsistencies and contradictory data in the documents, due to the discrepancy between the elaboration stages in which they were. Some information deemed essential for the publication of the summary was also lacking, which caused correspondence exchange, request of documents and of additional information, besides the accomplishment of technical meetings with the regulation.

### **IX.4.2. Granting of the construction authorizations (ACs)**

Seeking knowledge that would help in the project analysis, members of the ANP WG participated of the first international mission which included visits to LNG regulating agencies and industrial facilities of the United States. The knowledge acquired by the study of the standards adopted in that country, as well as that of the projects forwarded by TAG, allowed the group to maintain deepened discussions with designers of international reputation, operators and regulating agencies of the LNG industry. It is worth to be mentioned the meeting held with the ABS Consulting team, which was the company responsible for the elaboration of the risk analysis studies of the Pecém and Guanabara Bay undertakings. The detailed description of the mission to the USA is mentioned in Chapter VI.

In view of Resolution CNPE no. 4 of November 21, 2006 and the need of gas supply to meet the energy demand, TAG elaborated an ambitious timeline for accomplishing the works, in which the gas pipelines' construction demanded a significant portion of the foreseen time. Furthermore, it was necessary to disassemble the Cearáportos facilities, intended for the transfer of liquid fuels, existing in the Pier 2 of Pecém.

In order to speed up the works accomplishment, it was decided to split the LNG piers' construction authorization in two: (a) the first one contemplated the construction of the gas pipelines and in the Pecém case, the dismantling of the liquids movement facilities, com the resulting revoking of the Cearáportos authorization; (B) the second one included the LNG and re-gasified natural gas movement facilities of the piers.

The experience accumulated by ANP in the pipelines' construction allowed the quick analysis of the relevant documentation forwarded with the resulting granting, on December 18, 2007

of the following authorizations.

- Authorization no. 464 for the construction of the Gas Pipeline Port of Pecém – Gasfor and for the dismantling of the movement facilities of liquid byproducts;
- Authorization no. 465, for the construction of the LNG Pier - Campos Elíseos Gas Pipeline.

In possession of the gas pipelines' AC's, TAG could start the construction works and so, make the fulfillment of the initial timeline stages feasible. In the meantime, the WG reviewed the information on the LNG transfer facilities and re-gasified natural gas reception, as well as the information on all the other equipment to be installed on the piers.

It should be pointed out that ANP is in charge of authorizing only the facilities in the pier and the natural gas outflow pipeline. The pier construction and the application of the reasonable regulation to the ships are the competence of Agência Nacional de Transportes Aquaviários (Antaq) and the Brazilian Navy, while the environmental licensing process is the responsibility of the relevant environmental agencies.<sup>15</sup> In Guanabara Bay, in particular, the Navy was also responsible for authorizing the submarine pipelines of potable water and fire water, as well as the submerged electric cables and fiber optics interconnecting the Pier to the Ilha D'Água and Ilha Redonda facilities. The division of competences described above is represented schematically in Figure IX.1. In the cases in which the licensing was not the ANP responsibility, manifestations of the relevant agencies were requested.

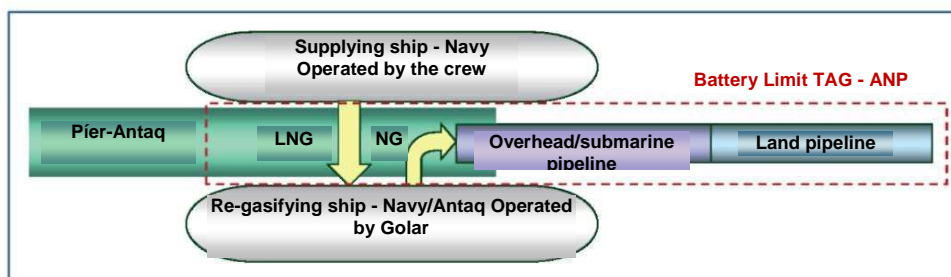


Figure IX.1 - Division of competences among the different regulating agencies.

ANP has requested the pronouncement of the following entities:

**Agência Nacional de Transporte Aquaviários (Antaq):** Construction and Exploration Authorization of the Guanabara Bay Port Terminal, intended for the movement of LNG and re-gasified natural gas. Regarding the Port of Pecém, Antaq advised that Pier 2 where the project would be implanted was already authorized by it, and a new authorization was not necessary.

**Brazilian Navy:** Opinion of the Rio de Janeiro Port Authority informed that it did not oppose to the pier construction, upon launching the submarine cables and to the implantation of the Guanabara Bay Pier utilities. A manifestation of the Navy for the Pecém Pier was not requested, since the Pecém LNG project was implanted on an already existing pier.

<sup>15</sup> The relevant environmental agencies are as follows: (a) in Rio de Janeiro, Instituto Estadual do Ambiente (Inea), which replaced Fundação Estadual de Engenharia do Meio Ambiente (Feema); (b) in Pecém, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Ibama).



**Instituto do Patrimônio Histórico e Artístico Nacional (Iphan):** Authorization for the company to perform works in the pipeline zone with the follow-up of archeologists, in order to preserve the Country's historic assets.

**Cearáportos:** The manager of the port facilities declared to ANP to be in negotiation with TAG so that the latter had priority in the liquefied natural gas (LNG) operations and natural gas in Pier 2 of the Port of Pecém.

Besides asking the manifestation of those public entities, ANP deemed necessary for following up the licensing processes and explanation of doubts during the analysis of the projects, to hold meetings and presentations with the designing and EPC members.<sup>16</sup>

Meetings with the following companies may be highlighted:

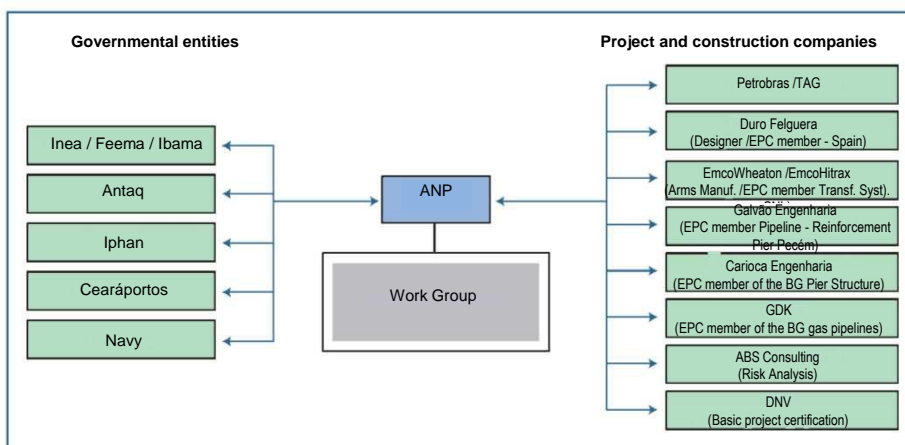
1. Petrobras and TAG, responsible for the projects;
2. Duro Felguera S.A., a Spanish company responsible for the basic project and of the piers' detailing, as well as for the skids manufacturing in Spain;
3. EmcoWheaton, a manufacturer of LNG loading and unloading arms and re-gasified natural gas unloading;
4. EmcoHitrax Engineering, the representative in Brazil of the company EmcoWheaton and subcontracted by Duro Felguera S.A. to build and manage the works in the LNG piers;
5. Galvão Engenharia S.A., an EPC of the gas pipeline interconnecting the Pier 2 of Port of Pecém to the MPX Filtration Station and responsible for conducting the reinforcement works and adaptation of the Pier 2;
6. Carioca Christiani-Nielsen Engenharia S.A. (Carioca Engenharia), an EPC responsible for the construction of the Pier structure of Guanabara Bay;
7. GDK S.A., an EPC of the onshore and offshore gas pipelines interconnecting the Guanabara Bay Pier (BG) to the Campos Elíseos Station;
8. ABS Consulting, a consulting company that elaborated the projects' risk analysis; and
9. Det Norske Veritas (DNV), a certification agency of the basic project of the piers.

Figure IX.2 summarizes the Agency interaction with the governmental agencies and with the companies involved in the project during the process of granting the ACs.

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<sup>16</sup> Neologism derived from EPC, the English Acronym for Engineering, Procurement and Construction prevailing, in large sized construction works in the Anglo-Saxon countries, the companies performing the basic project detailing build and manage the undertaking. The EPC contracts have common points with the outsourced contracts provided for in the Brazilian Civil Code.

<sup>17</sup> Skids are prefabricated modules for the subsequent assembly in the work site.



**Figure IX.2** - Interaction of ANP and Work Groups with the governmental entities and with companies involved in the project and in the construction of the LNG piers.

The process analysis and the meetings with the entities and companies involved contributed to the better understanding of the project, which decreased the correspondence exchange between Agency and regulated agent. The complexity of the projects led to the request of a large amount of information through correspondence. For the Pecém project, 21 descriptive and calculus logs were required, besides 25 plans and flow charts. For the Guanabara Bay project, 14 logs and 24 plans and flowcharts were required.

The processes analysis reached the summit in the granting of the following authorizations for the LNG piers:

- Authorization no. 111 of March 18, 2008 published in DOU of 3/19/2008 for the LNG reception and transfer, and natural gas outflow facilities in Pier 2 of the Port of Pecém.
- Authorization no. 130 of April 8, 2008 published in DOU of 4/19/2008 for the LNG reception and transfer, and natural gas outflow facilities in Guanabara Bay Pier.

### IX.4.3. Granting of the operation authorizations (AOs)

Normally, the operation authorizations (AO's) are granted when all documents listed in Art. 9 of Ordinance ANP no. 170/1998 are presented, which includes the forwarding of a commissioning certificate without the work fluid. However, due to the originality of the projects, the work group introduced an intermediate step between AC and AO, which was denominated "temporary operation authorization" (ATO). The ATO would be granted through the presentation of commissioning certificates without the utilization of the work fluid, along with all the other documents listed in that article.

The purpose of the creation of this additional step was to make the fine tuning and monitoring of the facilities feasible, thus contributing to more safety in the operations. The commissioning certificates using only inert fluid were denominated "pre-commissioning certificates". The granting of operation authorization proper would only occur after the forwarding of new certificates, elaborated from essays using the work fluid, in that case, the natural gas.



For the granting of the ATO's, partial pre-commissioning certificates were requested for each system deemed critical, in order to make sure that all were contemplated in the final commissioning certificate. The systems deemed critical were the following:

Electric, automation and instrumentation facilities;

- Firefighting system;
- Nitrogen system;
- LNG loading/unloading and re-gasified natural gas unloading arms;
- Pipelines on the pier and knock-out drum;
- Mooring and ship-shore link system;

The pre-commissioning certificates were required only for the facilities on the piers. For the case of gas pipelines connecting the piers to the respective gas distribution stations, ANP adopted the standard procedure of AO granting, directly with the commissioning certificate issued without the utilization of the work fluid. That occurred due to the large natural gas inventory which would be necessary for the commissioning of such facilities, with the resulting destination of the product. The commissioning certificates issued for the gas pipelines are mentioned in Table IX.1.

**Table IX.1** - Commissioning certificates of the gas pipelines.

Certifier	Object
ABS	Commissioning certificate of the Pecém Pier Gas Pipeline
ABS	Commissioning certificate of the Guanabara Bay LNG Project submarine gas pipeline
ABS	Commissioning certificate of the Guanabara Bay LNG Project onshore gas pipeline
ABS	Commissioning certificate of the Guanabara Bay LNG Project onshore gas pipeline – stretch of the temporary interconnection with Gasduc II
DNV	Commissioning certificate of the Guanabara Bay LNG Project onshore gas pipeline –stretch of the definitive interconnection with Campos Elíseos Station.

The pre-commissioning certificates issued for the facilities on the Pacém and Guanabara Bay LNG Piers are presented in Tables IX.2 and IX.3 respectively.

**Table IX.2** – Pre-commissioning certificates issued for the Pecém Project.

Certifier	Object
DNV	Commissioning certificate of the N <sub>2</sub> system
DNV	Commissioning certificate of the Arm no. 7 (re-gasified natural gas)
DNV	Commissioning certificate of the Firefighting and Gas Detection System
DNV	Pre-Commissioning certificate of the pipelines, knock out drum (KOD), mooring, gangway (VT) and ship-shore link
DNV	Pre-Commissioning certificate of the Wiring System
DNV	Pre-Commissioning certificate compiling the partial certificates

**Table IX.3 – Pre-commissioning certificates issued for the Guanabara Bay Project.**

<b>Certifier</b>	<b>Object</b>
DNV	Pre-commissioning certificate of the N <sub>2</sub> system
DNV	Pre-commissioning certificate of the LNG Transfer Arms no. 1 to 6
DNV	Pre-commissioning certificate of the Firefighting and Fire Detection System
DNV	Pre-commissioning certificate of the pipelines, knock out drum (KOD), mooring, gangway (VT) and ship-shore link
DNV	Pre-commissioning certificate referring to the Wiring System
DNV	Pre-commissioning certificate compiling the partial certificates of the LNG Transfer Arms no. 1 to 6
DNV	Pre-commissioning certificate compiling the partial certificates of the NG Transfer Arms no. 7 and 8

For the granting of the ATO's, ANP also required all the other documents listed in Art. 9 of Ordinance no. 170/1998, namely: the operation licenses issued by the relevant environmental agencies (Ibama in Pecém and Inea in Guanabara Bay) and the maintenance and repair plans. ANP received 64 maintenance and inspection plans of the Pecém LNG Project and 49 of the Guanabara Bay Project.

For granting the final AO, ANP required the presentation of the piers facilities commissioning certificates using natural gas, the accomplishment of simulations (see item IX.4.5) and a series of revised documents for the "as built" version.

During the analysis process the work group also requested the pronouncing of other governmental agencies, namely:

**Brazilian Navy:** Temporary instructions of Rio de Janeiro Port Authority for the entrance and permanence of the LNG ships in the Port of Rio de Janeiro and ordinance changing the rules and procedures of Ceará Port Authority;

**Conportos and Cesportos** (Brazilian Committee of Public Safety in; and State Public Safety Committees in the Ports, Terminals and Seaworthy Waterways): issuing of compliance Certificates to the International Ship and Port Facility Security Code, ISP Code;

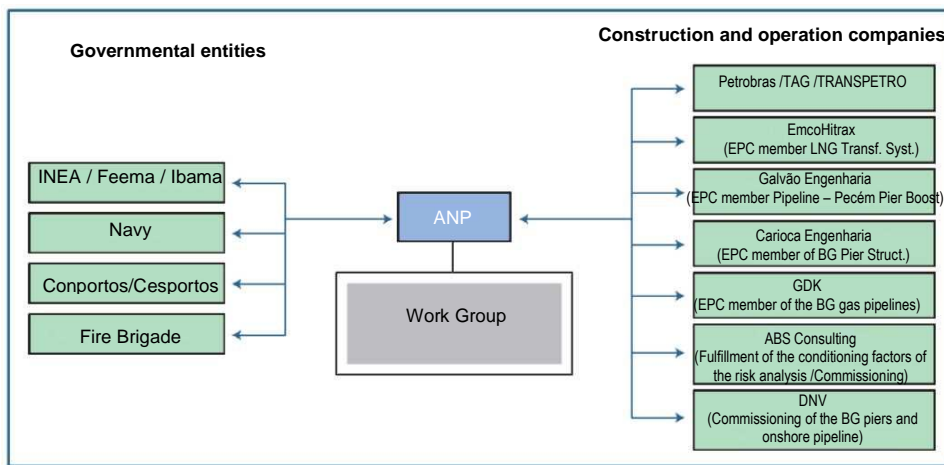
**Rio de Janeiro and Ceará Fire Brigades:** Dispatch certificates and inspection report certifying the compliance of the fire prevention and fighting systems.

Like what was seen in the AC's granting process, the holding of meetings and presentations with the companies involved in the facilities construction, commissioning and operation was deemed necessary. Thus, meetings were held again with the EPC members EmcoHitrax Engineering, Galvão Engenharia S.A., Carioca Christiani- Nielsen Engenharia S.A. (Carioca Engenharia) and GDK S.A., to discuss constructive aspects of the works and changes in project that were made. Additionally Transpetro entered the meeting cycle, for being the company that would become the operator of the piers and gas pipelines.

Additional meetings were held with the participation of the certifying companies ABS Consulting and Det Norske Veritas (DNV). In those occasions, ABS presented the fulfillment of the Risk Analysis conditioning factors that it had elaborated during the AC request and of the installation license of the project to the environmental agency. The criteria used in the commissioning of the Porto de Pecém-MPX Filtering Station and of the submarine part of the LNG-Campos Elíseos Station Pier gas pipeline which were under its responsibility, were also

presented. In an analogous form, DNV presented the criteria adopted for the commissioning of the LNG Piers facilities and of the onshore part of the LNG-Campos Elíseos Station Pier gas pipeline.

Within the period between the granting of the ACs and the first ATO's of the piers, ANP met weekly with Petrobras/TAG for acknowledging the works evolution and of the expected timeline changes, in order to meet Art. 8 of Ordinance no. 170/1998. The interconnection of the Agency with the governmental agencies and with the companies involved in the construction, assembly, commissioning and/or operation of the facilities is schematically presented in Figure IX.3.



**Figure IX.3** - Interaction of ANP with the governmental entities and with companies involved in the LNG piers construction, assembly, commissioning and operation.

The LNG Project of Pecém forwarded all necessary information and documents to the AO, which was granted on June 2, 2009 by means of the ANP Authorization no. 282 published in DOU of 6/3/2009. In its turn, the AO of the LNG Project of Guanabara Bay was granted on October 16, 2009, by means of the ANP Authorization no. 487 published in DOU of 10/19/2009. The list of the commissioning certificates, of the ATO's and the AO's of the projects are mentioned in Tables IX.4 to IX.7.

Due to the project's emergency character and as a result of problems in the construction and assembly of the systems, as they were being completed and commissioned without the work fluid, ANP was granting the partial ATO's. This procedure was adopted by TAG's request, to minimize the impacts of those occurrences on the projects' timelines, on the availability of the LNG importing ships and on the fulfillment of the gas supply contracts for the thermal-electric power stations. Thus, the project counted on ATO's that contemplated, in a case, only the LNG transfer system and in the other case, the movement of the re-gasified natural gas. In the case of Pecém, there was even the ATO granting for a single natural gas unloading arm and pipeline.

**Table IX.4 – Commissioning certificates issued for the Pecém LNG Project.**

Certifier	Object
DNV	Commissioning Certificate with Natural Gas of Arm no. 7
DNV	Commissioning Certificate with NG of the Arms nº 1 to 6 (LNG) and no. 7 and 8 (Natural Gas)
DNV	Global System Commissioning Certificate

**Table IX.5 – Authorizations granted for the Pecém Project.**

Authorization	Date	Description
ATO	01/07/2009	Temporary Operation Authorization no. 4/09 for the commissioning of the Arm no. 7 (GNC) and the Gas pipeline LNG Pier - Gasfor
ATO	03/31/2009	New Temporary Operation Authorization no. 178/09 for the Arm no. 7 (GNC) and the Gas pipeline LNG Pier - Gasfor
ATO	04/07/2009	Temporary Operation Authorization no. 183/09 for the commissioning of all the other arms and pier facilities
AO	06/02/2009	Operation Authorization no 282/09 for the Pecém LNG Pier facilities and for the gas pipeline interconnecting the Port of Pecém to Gasfor 20"

**Table IX.6 – Commissioning certificates issued for the Guanabara Bay Project.**

Certifier	Object
ABS	Commissioning Certificate of the submarine gas pipeline
ABS	Commissioning Certificate of the onshore gas pipeline – stretch of the temporary interconnection with Gasduc II
ABS	Commissioning Certificate of the onshore gas pipeline
DNV	Global Commissioning Certificate of the LNG Pier facilities

**Table IX.7 – Authorizations granted for the Guanabara Bay Project.**

Authorization	Date	Description
ATO	03/10/2009	Temporary Operation Authorization no. 148/09 for the commissioning of the LNG transfer arms
ATO	03/25/2009	Temporary Operation Authorization no. 175/09 for the commissioning of all the other arms and pier facilities
ATO	05/12/2009	Temporary Operation Authorization no. 222/09 for the gas pipeline interconnecting the Guanabara Bay LNG Pier to Campos Elíseos Station.
ATO	05/27/2009	New Temporary Operation Authorization no 267/09 for the transfer facilities of the LNG Pier and of the gas pipeline interconnecting the pier to Campos Elíseos Station
ATO	06/10/2009	New Temporary Operation Authorization no 298/09 for the transfer facilities of the LNG Pier and of the gas pipeline interconnecting the pier to Campos Elíseos Station
ATO	08/13/2009	Temporary Operation Authorization no 378/09 for the transfer facilities of the LNG Pier and of the gas pipeline interconnecting the pier to Campos Elíseos Station
AO	10/16/2009	Operation Authorization no nº 487/2009 for the Guanabara Bay LNG Pier gas facilities and for the gas pipeline interconnecting the LNG Pier to Campos Elíseos Station

During the authorizations' process, there was a constant correspondence exchange between ANP and TAG. In view of the project's originality, several additional documents were requested aiming to check which steps were being taken for the safe operation of the facilities. Based on the sole paragraph of Art. 10 of Ordinance ANP no. 170/1998 more than 270 additional documents were requested for the two projects, which contributed to the work group learning.

#### IX.4.4. Inspections

It is part of the standard ANP procedures to make an inspection of the facilities before the granting of their AO's. In the case of the LNG projects, once the construction of the facilities is started, the ANP team performed not one, but a series of inspections, aiming to follow-up the works development. In the whole, 13 inspections were made, seven in Pecém and six in Guanabara Bay, such as identified in Table IX.8.

**Table IX.8** – Inspections made by ANP to the LNG projects' facilities of Pecém and Guanabara Bay.

Pecém		Guanabara Bay	
Date	ANP organizational units*	Date	Organizational units
05/25/2008	SCM and SRP	05/07/2008	SCM and SRP
08/19/2008	SCM and SFI**	12/10 and 11/2008	SCM and CSO
10/22 and 23/2008	SCM and CSO	01/21/2009	SCM, SRP, CMA and CSO
11/17 and 18/2008	SCM, CSO and CMA	02/10 and 11/2009	SCM, SRP, CMA and CSO
12/28 and 29/2008	SCM and CSO	02/26 and 27/2009	SCM and CSO
02/18 and 19/2009	SCM, SBQ, SRP and CSO	03/11 and 12/2009	SCM and CSO
03/09 and 10/2009	SCM, SRP and CSO		

•ANP Units comprising the Work Group: Superintendence of Commercialization and Movement of Petroleum, its Byproducts and Natural Gas (SCM); Superintendence of Refining and Processing of Natural Gas (SRP); Superintendence of Biofuels and Products Quality (SBQ); Coordination of Operational Safety (CSO); Coordination of Environment (CMA).

\*\* Superintendence of the Supply Inspection (SFI). SFI is not part of the work group but was requested for this inspection.

#### IX.4.5. Simulations

In order to grant operation authorizations, ANP requested that the accomplishment of operation simulations in the facilities so that the company could evaluate the performance of the teams involved with the operating activities, the response time, the adequacy of the Emergency Plans, as well as to detect possible training faults.

The simulation of the LNG project in Pecém was held on May 13 and 14 2009 and counted on the participation of Petrobras' Transpetro, the Port Administration of Pecém, and Ceará Port Authority and Fire Brigade. The simulated accident consisted in a natural gas leakage at 85 kgf/cm<sup>2</sup> in the SDV-28 blocking valve flange, simultaneously with the LNG re-gasification - process in the ship Golar Spirit and to the emission of gas to the thermal-electric companies in the region. At the moment of the accident, a work team was performing assembly activity in the scaffold, with the due Work Permit in the Pier Facilities. The workers were using a mallet that was unsuitable for the service, which generated unforeseen sparking and the resulting ignition of the flammable atmosphere. Additionally, two victims were simulated, one directly involved with operating activities in the surrounding area of the SDV-28 and the other farther from the site. The simulation was followed up by ANP.

The simulation of the Guanabara Bay project was foreseen for May 27, 2009.

However, the event was postponed for safety reasons, since conflicts aroused between the companies involved in the project and the community of fishermen in the region. The simulation was appointed again for September 10 of that year, and just as with Pecém, it involved also the flange rupture of the natural gas line blocking valve interconnecting the Pier to the distribution station. The event simulated an accident, with one victim, including gas leakage, followed by flash and fire, during the accomplishment of maintenance works in the Pier facilities. Members of the Pier operators, the help teams of Ilha d'Água and of Ilha Redonda, the Federal Police, the Fire Brigade, the Military Police of the State of Rio de Janeiro and the Galeão Air Force Hospital, where the supposed victim was sent to, participated in the simulation. The event was followed up by members of the ANP work group, of the Port Authority, of the Port Authority of Rio de Janeiro and Inea.

## **X. EXPERIENCE FOR THE REGULATING AGENCY**

Upon starting the analysis processes of the Pecém and Guanabara Bay LNG projects, ANP deemed necessary that, due to the dimensions and innovating characteristics of the project, the work was done by a multi-disciplinary group. The Work Group formation was essential for the efficiency and quality of ANP's action, upon allowing that the team of the organizational unit responsible for the theme, SCM, had the support of the Agency areas working with aspects related to the environment, process, product quality and operating safety. The joint action of the servers from several ANP areas allowed the constant exchange of experiences, thus potentizing the Agency learning as a whole.

In order to overcome the difficulties found, procedures and systems were developed, as the following ones:

- Sharing of the administrative decision of granting the authorizations between ANP's Collegiate Board, superintendence and coordination;
- Division of the process in parts, in order to grant partial authorizations allowing the fulfillment of timelines with no harm of the compliance to the technical and legal requirements by the entrepreneurs and executors of the projects;
- Establishment of Temporary Operation Authorizations (ATOs);
- Accomplishment of technical inspections for following up the advance of the construction works of the Piers; and
- Follow-up of the emergency fight simulations.

The Work Group creation, the analysis of the documentation forwarded by TAG, and the study of the standards which the projects were based on, allowed ANP to potentize the acquisition of the involved employees' knowledge. The meetings held with the TAG team with the participation of designers and EPC members, were an extremely effective method for the quick clarification of the doubts aroused by the Agency. Thus, the technical body involved in the task – and by means of the work group, the Agency as a public entity – accumulated an important regulatory experience.

Additionally the knowledge accumulated by the Agency was considerably expanded with the accomplishment of the international missions to the United States, Spain and United Kingdom, described in Chapter VI. Those missions included visitations to LNG facilities, both under construction and in operation, besides meetings with regulating agencies, internationally renowned consulting companies and with terminals' operators and ships of those countries.

Thanks to the international missions, it was possible to find that for the better progress of the projects, procedures currently used in the worldwide LNG industry should be adopted in Brazil. ANP has realized that for the development at an ideal pace of projects of the kind, one should assure a consistent management of the foreseen steps, contemplating the accomplishment of HAZOP's at the end of each one of them or after any change, with the adoption of procedures for managing changes.

The international experience shows that the following practices should also be complied with:

- A profound study of the project should be made before the construction starts, elaborating cause and effect matrixes and identifying the interlocks. Those studies should not be in charge of the EPC member, since they should contemplate the philosophy of the contracting company, as well as its operation, operating safety and environmental preservation procedures.
- A third party independent of the designer and of the EPC member should be contracted to follow-up and certify all steps of the project.
- The operating and commissioning procedures should be elaborated and approved before the construction starts, since they can bring substantial changes to the project. In case the company does not have a vast experience in the area, the commissioning, operation and startup procedures of the plant should be elaborated by a third party with notorious knowledge in the area.
- It should be assured during the construction and assembly steps, that the equipment are duly protected, to assure that they remain dry and clean for the commissioning.

It should be pointed out that the work group creation was very important in the process of granting the authorizations. The joint action of the ANP areas with expertise in very different segments (gas and byproducts movement, refining and natural gas processing, products quality, operating safety and environment) allowed a large experience exchange and the acquisition of knowledge by the Agency as a whole. In its turn, TAG/Petrobras did not spare efforts to meet the ANP requests, which certainly collaborated for the learning of all those involved to be successful.

## **XI. FINAL CONSIDERATIONS**

Up and coming, the LNG industry has been playing an outstanding role in the worldwide energy panorama. The utilization of this modal has been evolving very fast, given the need of most of the countries to diversify their gas supply sources and to assure their domestic supply.

Performed and accomplished in this international energy context, the TAG LNG projects the constructions and operation authorizations of which were requested to ANP, allowed the

Agency to act in an efficient way, with much collaboration, exchange of experiences, information and knowledge among its different technical areas (between superintendence and coordination), an experience that is very useful in the process of forming the Agency's technical body.

In the international missions, it was possible to deepen not only the knowledge regarding the LNG terminals, but also to study and discuss operating and regulatory aspects of the whole natural gas chain, focusing on the safety and regulation.

The meetings between the ANP and Petrobras/TAG teams with the participation of designers and EPC members, have shown to be an effective instrument for the quick clarification of doubts aroused by the Agency. Such integration resulted in the accomplishment of a joint international mission to Spain for standardization of the learning.

Finally, the acquired experience shall enable, undoubtedly to improve the revision of the technical and economic issues mentioned in the ANP ordinances and resolutions related to requests of facilities' construction and operation authorizations.



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